AIDGAP
TESTED

AN ILLUSTRATED GUIDE TO THE DIATOMS OF BRITISH COASTAL PLANKTON

By J. B. SYKES

Department of Environmental and Geographical Studies, Manchester Polytechnic

ABSTRACT

Following introductory sections on the structure and ecology of marine diatoms, a key is provided to some sixty forms most likely to be encountered in plankton samples from British coastal waters. A draft version of the key was subjected to extensive user-testing (a feature of all AIDGAP keys) and many of the resulting comments have been incorporated in the present paper.

INTRODUCTION

There are, at present, 118 genera of marine diatoms on the British list (Hendey, 1974) and representatives of any of them could be found in plankton samples collected near the coast. The aim of this guide, however, is to help the student gain entry to the microscopic world of the phytoplankton and, to this end, some sixty forms have been selected as those most likely to be encountered in samples from British coastal waters.

For descriptions of diatoms not included here, reference should be made to the works of Van Heurck (1896), Lebour (1930), Hendey (1964) and Drebes (1974).

Nomenclature used in this guide follows Hendey (1974), which has several changes from that used in the earlier works. Nomenclature changes are noted at appropriate points in the text of the key. An index of the genera and species included in the key can be found on pages 466-467.

The key is an artificial one, and cuts across the accepted taxonomy. In most cases, identification is to species but sometimes, where specific indentification depends on characters that are not readily discernible with the microscopes normally available for class use, the key goes only to the generic level.

To help the student to understand his phytoplankton samples and the diatoms they contain, there are sections on diatom structure and ecology. These are necessarily rather brief and a list of key references is provided, from which further details may be obtained.

WHAT IS A DIATOM?

Diatoms are single-celled plants that form the Class Bacillariophyceae of the Algae. They are typically aquatic, although some can be found in damp terrestrial habitats. In the sea, diatoms live on the mud and sand of the sea bed, and on the surface of rocks and seaweeds, as well as floating freely in the water. Here they form an important part of the planktonic plant community which is usually called the phytoplankton. They carry out much of the marine primary production and can be conveniently thought of as "the grass of the sea".

Each diatom has a more-or-less heavily silicified cell wall, the *frustule,* which is a characteristic of the class. It consists of two slightly unequal halves (Fig. 1), each composed of a valve attached to a girdle band. The larger valve and girdle band fit over the smaller like the lid of a box. The diatom may present two quite different views when seen down a microscope: a full view of either valve surface, the *valve view,* which in this case is circular; or a side view, the *girdle view,* in which the turned-
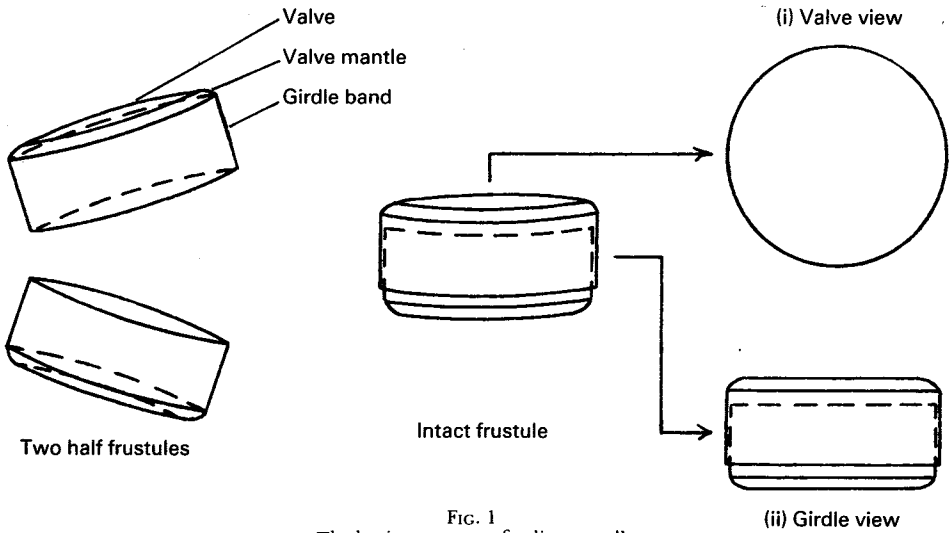
FIG. 1
The basic structure of a diatom cell

down edges of the valves (valve mantles) and the overlapping girdle bands are visible. In this example the girdle view is rectangular.

Diatoms exhibit a great range of cell shapes, a feature of which much use is made in the key. Two major groups are generally recognised on the basis of the symmetry of the cell and of its surface sculpturing when seen in valve view; namely, *centric diatoms* and *pennate diatoms*.
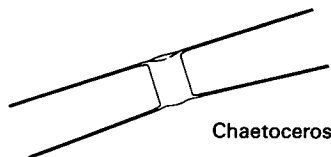
Centric diatoms are characteristically, but not exclusively, planktonic. They are radially symmetrical in valve view, with the pattern of sculpturing based on a central point as exemplified by *Coscinodiscus radiatus.*
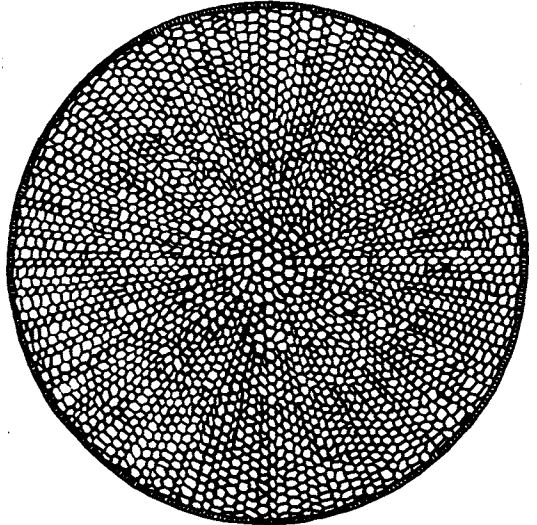
In other genera, however, this "pill box" shape is less apparent; e.g. *Rhizosolenia,* in which the valve is often conical and the girdle length may be up to fifty times the valve diameter, and *Chaetoceros,* in which long spines, called setae, arise from the valves.
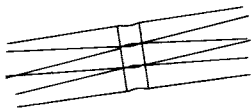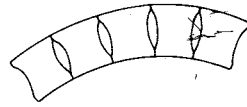
Many centric diatoms also form chains of cells, in which the cells are joined together by all, or part of, their valve surfaces. Three such genera are:

Chaetoceros   Lauderia   Eucampia

In other genera, the cells are linked in chains by spines e.g. *Skeletonema*

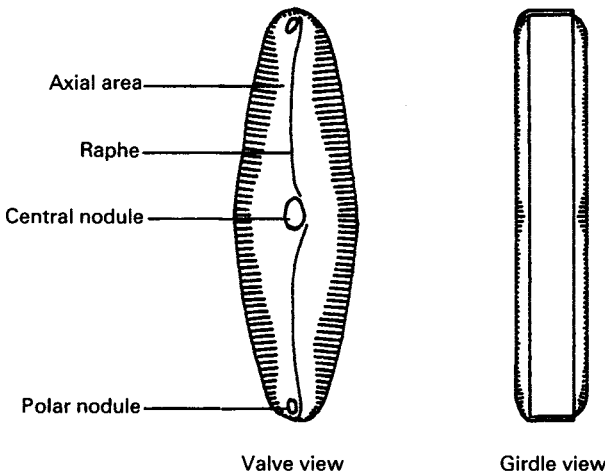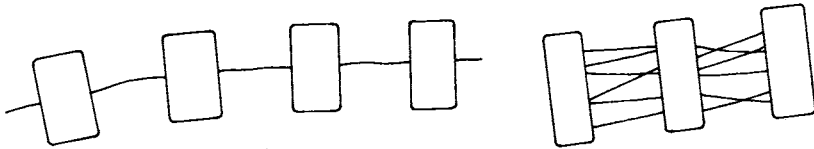or by mucilaginous threads arising from the valve surface, as in *Thalassiosira:*

Axial area

Raphe

Central nodule

Polar nodule

Valve view   Girdle view

Fɪɢ. 2. The structure of a generalised raphe-bearing pennate diatom.

Pennate diatoms are bilaterally symmetrical in valve view, with a different pattern of surface sculpturing, based on a central line, as illustrated in Fig. 2. The valve has a more-or-less narrow axial area with thickening in the centre, the central nodule, and at each end, the polar nodules. Running between the nodules in many genera, e.g. *Navicula,* are two narrow slits which form the raphe. Most raphe-bearing diatoms live on the various solid surfaces of the sea bed and the shore, where the raphe is associated with a characteristic, jerky, cell movement. However, representatives of many such genera occur in the plankton, especially when stormy conditions have swept them into the surface waters. In other genera, which are more commonly planktonic e.g. *Asterionella,* there is no raphe.

Many pennate diatoms typically have their cells united in various ways to form colonies e.g.

Bacillaria paxillifer

Asterionella glacialis

Thalassionema nitzschioides
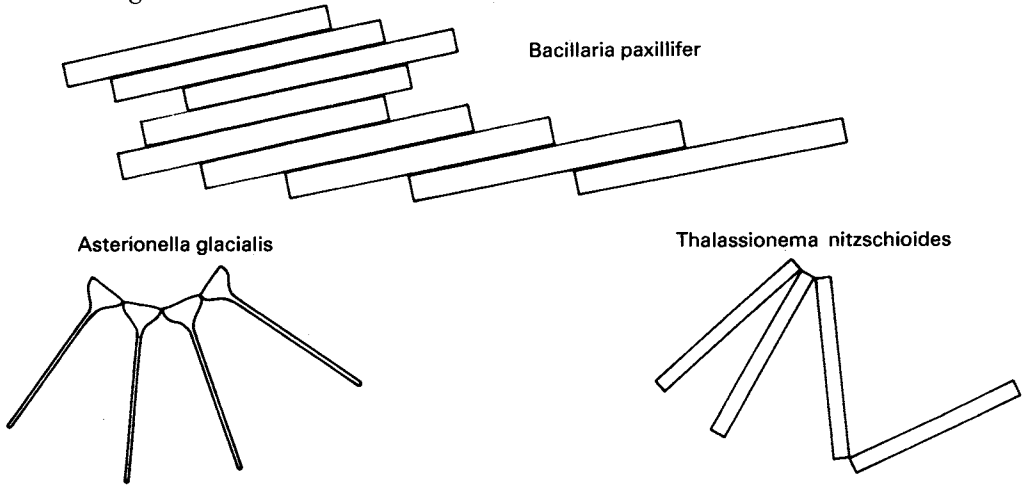
Diatoms are photosynthetic organisms and therefore contain chlorophyll. This is located within the cell in structures called chromatophores. These usually appear yellow or brownish in living cells because the green colour of the chlorophyll is masked by the presence of several carotenoid pigments. The shape and number of the chromatophores in fresh material are features much used in the key.

A further important point results from the type of cell division shown by diatoms. During division, new valve and girdle bands are formed inside each half of the parent frustule. Thus, in each generation, one of the daughter cells is fractionally smaller than the parent. This is illustrated in an exaggerated form in Fig. 3.

Parent frustule in girdle view

Two daughter frustules in girdle view

New valves and girdle bands are indicated by broken lines
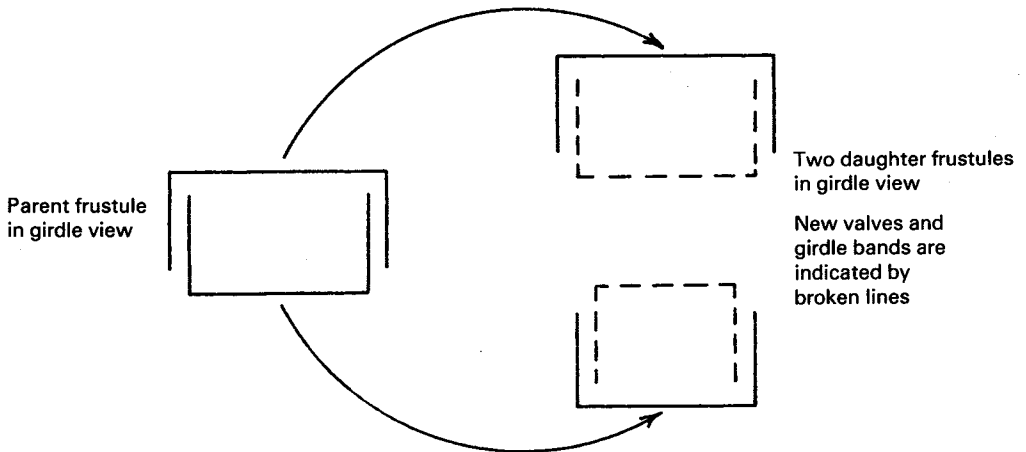
FIG. 3
Diagrammatic representation of diatom cell division.

Over succeeding generations, this can result in a considerable difference in size between members of the same species. Therefore, valve diameter is not a sound character in the description of diatoms. Nevertheless, some species are typically much larger than others, and the usual size range of each form is given in the key,

but it is generally intended to be used as confirmatory rather than diagnostic evidence.

The progressive reduction in cell size, that results from repeated cell division, eventually reaches a critical point. The cell then stops dividing, the living contents enlarge, and typically become rounded, to form the auxospore. Eventually, a new frustule is formed and the cycle restarts, as outlined in Fig. 4. If conditions are unsuitable for futher cell division, the auxospore may develop into a resting stage.
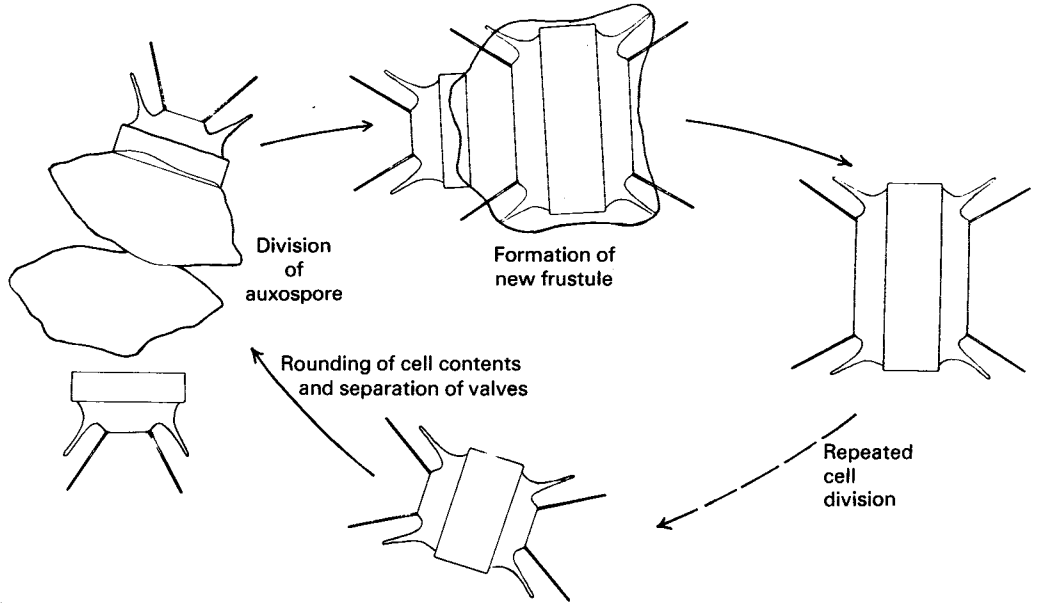
FIG. 4.
Cell division and auxospore cycle in *Biddulphia mobiliensis*.

DIATOM ECOLOGY

Our seas can be conveniently divided into two zones; the *neritic* zone, close to land, where the sea overlies the continental shelf and is relatively shallow; and the *oceanic* zone, which lies further offshore, beyond the limits of the continental shelf (see Fig. 5). This guide is concerned with the diatoms found in the neritic zone.

As with any ecosystem, the neritic plankton has its producers, consumers and decomposers, all interacting with their physical environment and with adjacent ecosystems. The producers are the floating plants of the plankton, the phytoplankton, and as the primary producers of organic matter in the sea, their role is fundamental to the functioning of the ecosystem. The most conspicuous members of the neritic phytoplankton are nearly always the diatoms.

Because the neritic zone is close to land, it is usually relatively enriched by the minerals that are constantly being eroded from the land and transported to the sea in rivers and other freshwater run-off. This mineral enrichment, particularly near estuaries, is often sufficient to support vigorous growth of diatoms and other members of the phytoplankton, so that the concentration of these organisms close to the shore is often much greater than that further offshore.

Our coastal waters are also the recipients of a vast array of pollutants. Some of

these, such as sewage, are rich in plant nutrients like nitrogen and phosphorus, and therefore encourage vigorous diatom growth. Some species, such as *Biddulphia aurita, Skeletonema costatum* and *Lithodesmium undulatum* seem to be particularly associated with areas of high organic pollution like the Thames estuary (El-Maghraby, 1956) and Southampton Water (Savage, 1965). Other pollutants may be correlated with the absence, or poor growth, of certain species. As an example, the coastal waters of Cardigan Bay, around Aberystwyth, have for many years received a polluting supply of heavy metal residues (notably, lead and zinc) from the numerous former mine workings in the area (Ireland, 1973, 1974) and the phytoplankton of this area generally lacks several species, e.g. *Eucampia zoodiacus* and *Skeletonema costatum,* that are common in other Welsh coastal waters (Sykes and Boney, 1970).
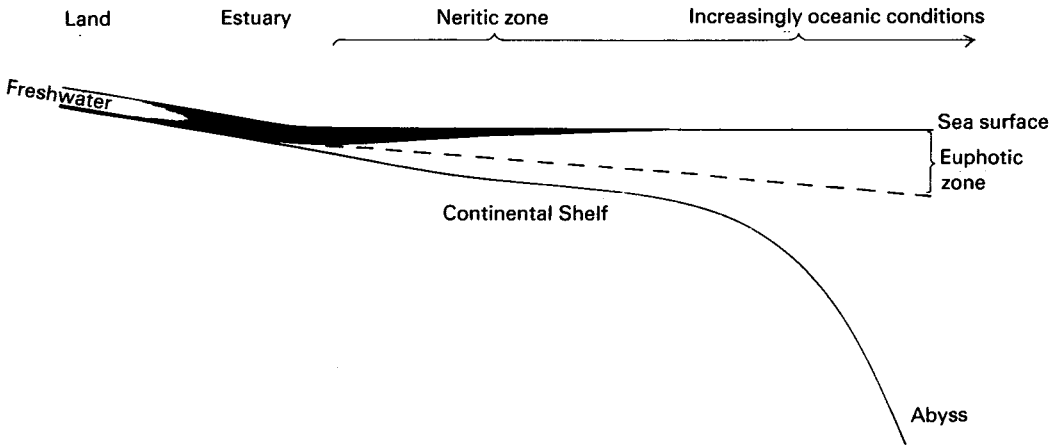
FIG. 5.
Zones in the sea.

The sea, like bodies of freshwater, may undergo thermal stratification during periods of warm, calm weather. This is because the warmer water at the surface is less dense than the colder water below. In the absence of winds or other mixing influences, a marked discontinuity can develop between the warm surface layer and the deep, colder water. This discontinuity is called the thermocline. Diatoms, as photosynthetic organisms, can only live and grow actively down to the depth to which enough light penetrates to permit adequate photosynthesis. Diatom production is thus effectively confined to a zone near the surface of the sea, the euphotic zone. The depth of the euphotic zone is variable and depends on incident sunlight and the amount of suspended material in the sea. In British coastal waters it may be only 10m. As diatoms and other planktonic organisms die, they sink out of the euphotic zone towards the bottom of the sea. There is thus a continuous drain of nutrients from the euphotic zone. If there is adequate mixing of the sea water, a supply of nutrients will be swirled up from the lower layers into the euphotic zone. If a thermocline is present, however, there will be no such mixing and the nutrients will remain unavailable to the diatoms, in deeper waters (see Fig. 6).

In many areas, there is a great increase in diatom numbers during the spring, as light and sea temperature increase. This spring "bloom" of the phytoplankton is followed by an increase in herbivorous zooplankton. For a time, diatom growth may keep pace with zooplankton grazing activity but, as a thermocline develops in

SOLAR RADIATION

Nutrients from land

PHYTOPLANKTON

ZOO-PLANKTON and LARGER ANIMALS

Sea Surface

Euphotic Zone

Seasonal Thermocline

Excretion, Defaecation Death and Sinking

Seasonal Vertical Mixing

Decomposition and Solution

Death and sinking
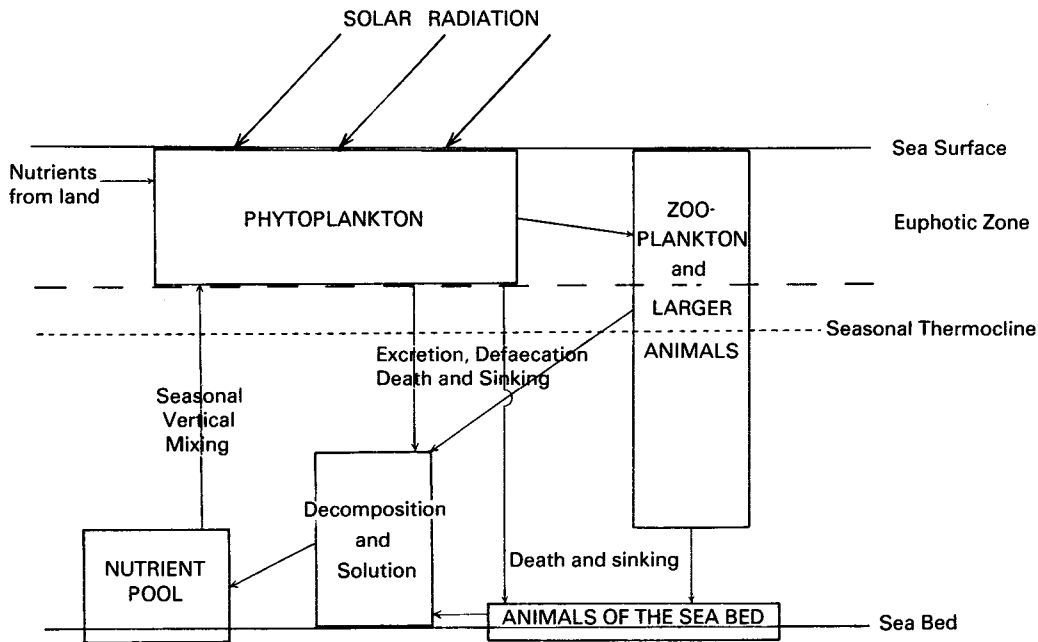
NUTRIENT POOL

ANIMALS OF THE SEA BED

Sea Bed

FIG. 6.
Simplified flow diagram of a neritic ecosystem.

the early summer, nutrients become limiting and diatom numbers may fall to a very low level in summer. Autumn gales bring about increased vertical mixing of the sea water, so that nutrients are again brought into the euphotic zone. It is for this reason that there is usually an autumn peak, or "bloom", of diatoms in our seas, before numbers are again reduced to a low level by the low temperatures and poor light availability of winter. These general, seasonal changes in the planktonic diatom community are illustrated in Fig. 7, and it follows that the numbers of diatom cells in standard samples collected at the same place, at different times of year, are likely to vary considerably.

In many shallow coastal waters, and other areas of turbulent mixing, a thermocline may not persist or be formed in summer, so that nutrients do not become limiting and diatom numbers remain high for much of the summer.

Within this overall picture is a succession of populations of different species so that the species found in an area on one occasion may be quite different from those found on a subsequent visit. There may, however, be some regularity in the sequence, as shown by a study in the vicinity of Aberystwyth (Sykes and Boney, 1970) where certain species were characteristic of particular times of year; e.g. *Thalassiosira* spp. were observed chiefly in spring, *Leptocylindrus* spp. in summer, and *Thalassionema nitzschioides* in autumn and winter. Other species were, to varying extents, more ubiquitous. It must by emphasised, however, that both the overall pattern of the sequence and its species composition often vary from place to place and, indeed, from year to year in the same place.

In addition to the truly planktonic diatoms that are fully adapted to life suspended in seawater, there are many that normally live on the shore or sea bed. Such forms are often found in coastal plankton samples, particularly after gales have
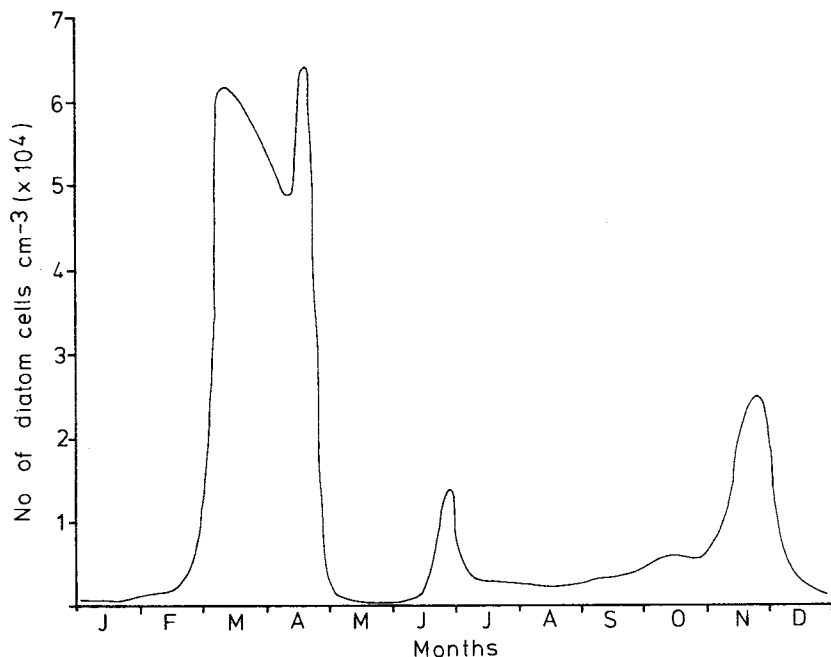
FIG. 7.
The variation in numbers of diatom cells in standard net samples collected off Aberystwyth during 1966.

swept them up into the surface waters. These cannot be called planktonic diatoms, but they may nevertheless be significant members of coastal plankton at certain times of year. Several of these forms have therefore been included in the key, particularly *Melosira* spp., *Navicula* spp. and *Paralia sulcata*. At Aberystwyth, *Navicula* spp. and *Paralia sulcata* were markedly associated with the winter and spring months.

Freshwater diatoms may also occur in coastal plankton, especially in estuaries. In such situations the guide of Belcher and Swale (1979) should also be consulted.

COLLECTING SAMPLES

Samples are best collected from a slowly moving boat, although satisfactory samples can often be obtained from the end of a pier or jetty. Samples collected directly from the shore usually contain a lot of detritus and many non-planktonic diatoms washed from rocks and other substrates. They are correspondingly more difficult to study.

The basic problems of collecting microscopic organisms from the sea and concentrating them to facilitate study are solved in two ways.

Plankton nets effect collection and concentration in the field but have the great disadvantage that their filtering efficiency varies widely, so that quantitative comparisons between samples are not very accurate. A net with 200 meshes per inch (mesh aperture size 0.054 mm) is best for collecting diatoms. It should be towed at such a speed that it just remains, fully extended, below the water surface. Samples can be collected from deeper water by attaching heavy weights to the net bridle and towing at a similar low speed. During a haul, the net will become progressively

clogged with accumulating plankton, and its filtering efficiency is thus drastically reduced. The duration of the net haul is therefore, to some extent, dependent upon the density of the phytoplankton. In dense phytoplankton, a haul of 5 or 10 minutes may suffice, at other times 20 or 30 minutes will be more appropriate.

The second method is more precise and simply involves collecting a sample of seawater and then separating the plankton from a known volume of water in the laboratory. A plastic bucket tied to a rope is quite adequate for surface sampling, but pumps and a variety of water samplers are used for more sophisticated studies. Various methods of separation are available; centrifugation and membrane filtration can be used, but sedimentation is often more appropriate. A known volume of seawater (200 cm^3 may be convenient) is poured into a measuring cylinder or similar vessel and 1 cm^3 (or in proportion) of Lugol's iodine solution is added. Lugol's iodine solution is made by dissolving 4 g of iodine and 6 g of potassium iodide in 100 cm^3 of distilled water. This fixes the organisms and they are then allowed to sediment to the bottom of the cylinder. The time required can be estimated at T = 3h where T = sedimentation time (hours) and h = height of sedimentation tube (cm). The water is then siphoned off and sub-samples of the concentrated plankton can be taken for examination.

Whichever sampling method is adopted, it is important to remember that planktonic populations are patchy in their distribution and that replication of samples is essential. For further guidance on this point see Elliot (1977).

PRESERVING SAMPLES

Whenever possible, samples should be examined in the fresh, living condition. If samples are allowed to stand after collection, two significant things can happen. Firstly, the animals in the sample will eat many diatom cells and damage many more; secondly, some plant species may divide very rapidly and assume a false abundance in the sample; *Cylindrotheca closterium* is a common diatom that often behaves in this way.

For short-term storage of a few hours, these effects can be reduced by keeping the samples cool in a cold room or refrigerator. Vacuum flasks are useful for transporting samples from the sea to the laboratory.

If samples are to be stored longer than overnight, however, a suitable preservative must be added to them. Lugol's iodine solution, described in the previous section, is suitable but neutral formalin, added to a final concentration of 2%, is also used.

Both these preservatives tend to distort the cell contents, so that caution is necessary when using characteristics like chromatophore shape to identify preserved diatoms.

EXAMINING SAMPLES

A conventional class microscope with × 10 and × 40 objective lenses is suitable for the examination of sub-samples mounted in seawater under a coverslip in the usual way. If larger diatoms are present in the sample, a cavity slide will be necessary.

The inverted microscope is particularly useful when sedimented plankton from

whole water samples is being examined. The combined sedimentation tube and counting chamber described by Evans (1972) is very useful here.

A moving stage is essential if counts of the different species are to be made. **In all such work it is important to remember that seawater is corrosive and should not be spilled on microscopes.**

REFERENCES

BELCHER, H. and SWALE, E. (1979). An illustrated Guide to River Phytoplankton. H.M.S.O., London.

ELLIOT, J. M. (1977). *Some Methods for the Statistical Analysis of Samples of Benthic Invertebrates.* Freshwater Biological Association, Cumbria.

EL-MAGHRABY, A. M. (1956). *The Inshore Plankton of the Thames Estuary.* Ph.D. Thesis, London.

EVANS, J. H. (1972). A modified Sedimentation System for Counting Algae with an Inverted Microscope. *Hydrobiologia,* **40** (2); 247-250.

HENDEY, N. I. (1974). A Revised Check-List of British Marine Diatoms. *Journal of the Marine Biological Association,* U.K., **54**, 277-300.

IRELAND, M. P. (1973). Result of Fluvial Zinc Pollution on the Zinc Content of Littoral and Sub-Littoral Organisms in Cardigan Bay, Wales. *Environmental Pollution,* **4**, 27-35.

IRELAND, M. P. (1974). Variations in the Zinc, Copper, Manganese and Lead Content of *Balanus balanoides* in Cardigan Bay, Wales. *Environmental Pollution,* **7**, 65-75.

SAVAGE, P. D. V. (1965). Preliminary Observations on the Phytoplankton of Southampton Water. *British Phycological Bulletin,* **2**, 515-516.

SYKES, J. B. and BONEY, A. D. (1970). Pollution and Inshore Phytoplankton. *Marine Pollution Bulletin,* **1**, 38-40.

SPECIALIST IDENTIFICATION BOOKS

DREBES, G. (1974). *Marine Phytoplankton.* Stuttgart.

HENDEY, N. I. (1964). *An Introductory Account of the Smaller Algae of British Coastal Waters, Part V: Bacillariophyceae (Diatoms).* Fishery Investigations, Ser. IV; H.M.S.O., London.

LEBOUR, M. V. (1930). *The Planktonic Diatoms of Northern Seas.* Ray Soc. 116, London.

VAN HEURCK, H. (1896). *A Treatise on the Diatomaceae.* Wesley, London. Reprinted in 1962.

ADDITIONAL READING

BONEY, A. D. (1975). *Phytoplankton.* Studies in Biology. No. 52; Arnold, London.

HARDY, A. C. (1970). *The Open Sea: Its Natural History. Part 1. The World of Plankton.* Collins, London.

NEWELL, G. E. and NEWELL, R. C. (1977). *Marine Plankton—A Practical Guide.* Hutchinson, London.

RAYMONT, J. E. G. (1980). *Plankton and Productivity in the Oceans. Vol. 1: Phytoplankton.* Pergamon, Oxford.

WIMPENNY, R. S. (1966). *The Plankton of the Sea.* Faber, London.

IDENTIFICATION—THE KEY

FIRSTLY, observe the shape of your cell carefully, viewing it as far as possible in both valve and girdle views. It is relatively easy to turn a cell over with a micropipette when using the inverted microscope and counting chamber. (Evans 1972).

Otherwise, with a water mount under a coverslip, it is often possible to turn a cell over by very gently moving the coverslip with a dissecting needle or similar instrument.

SECONDLY, decide which of the following groups (A-I) your specimen best fits into.

THIRDLY, follow the numbers given through the key.

Throughout the key, the individual cell is the unit to be considered. Some variable forms appear in more than one group and key out at more than one point.

Synonyms commonly used in older literature are given in parentheses where appropriate.

GROUP A   Cell shaped like a *disc* or *short cylinder* (length never more than twice width in girdle view) with *flat or weakly convex ends* and equal or unequal sides. The valve surface may have one or more spines or mucilage threads issuing from it
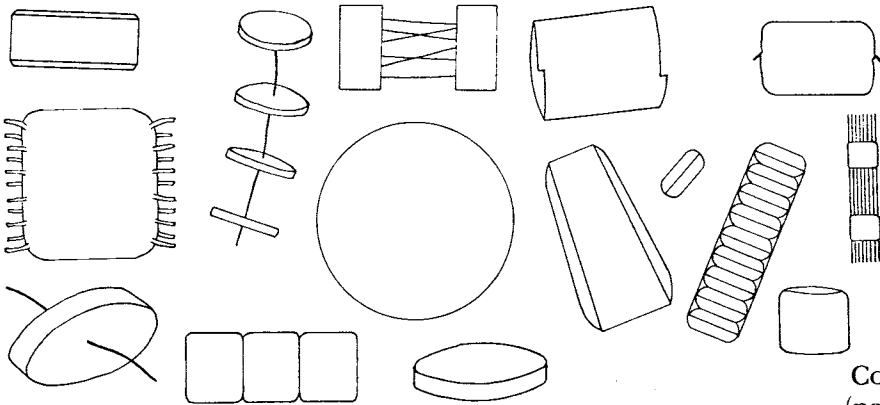
Couplet 1
(page 438)

GROUP B   Cell a *long cylinder* or *rod* (length considerably more than twice width in girdle view) with *flat ends;* cell straight or curved, may have a spine at each end
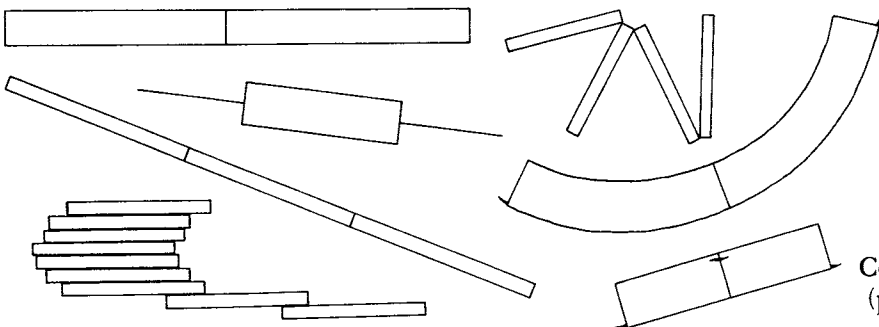
Couplet 14
(page 446)

GROUP C   Cell a *long or short cylinder* with *strongly convex ends;* may have a ring of spines at the valve margin.
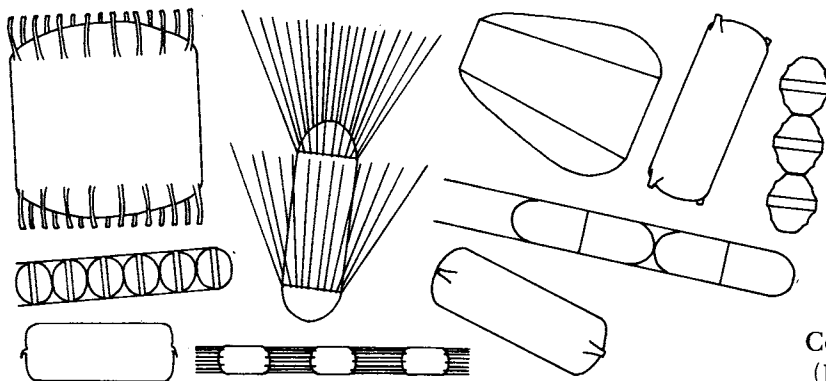
Couplet 19
(Page 448)

GROUP D   Cell *rod-shaped,* but with *dissimilar ends;* cells often united in spiral or star-like colonies
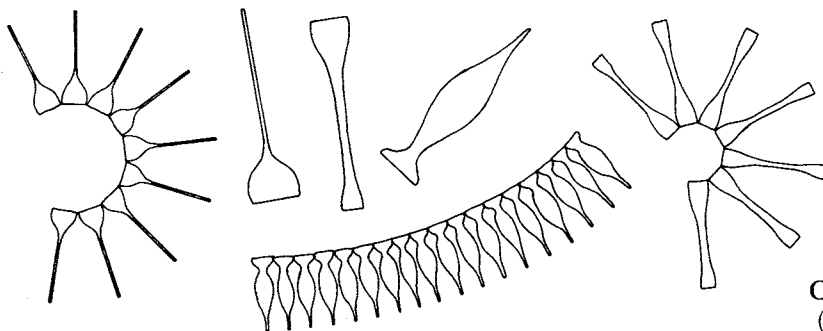
Couplet 23
(Page 452)

GROUP E   Cell *tapering to a point at each end*
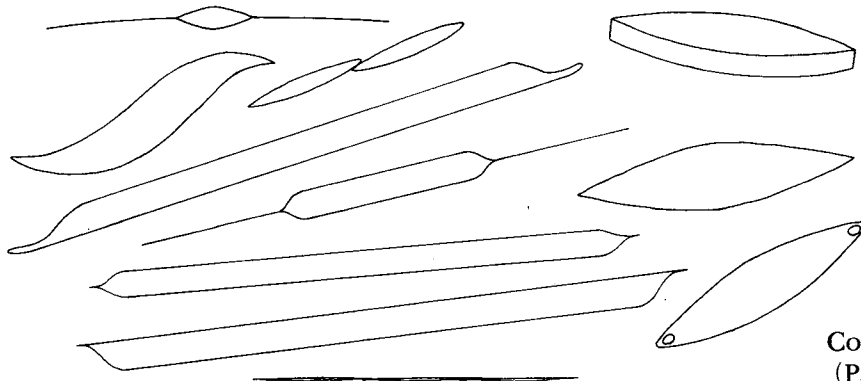
Couplet 24
(Page 453)

GROUP F Cell *cushion- or pillow-shaped,* with *extended corners;* may have two spines, between the corners, at each end of the cell
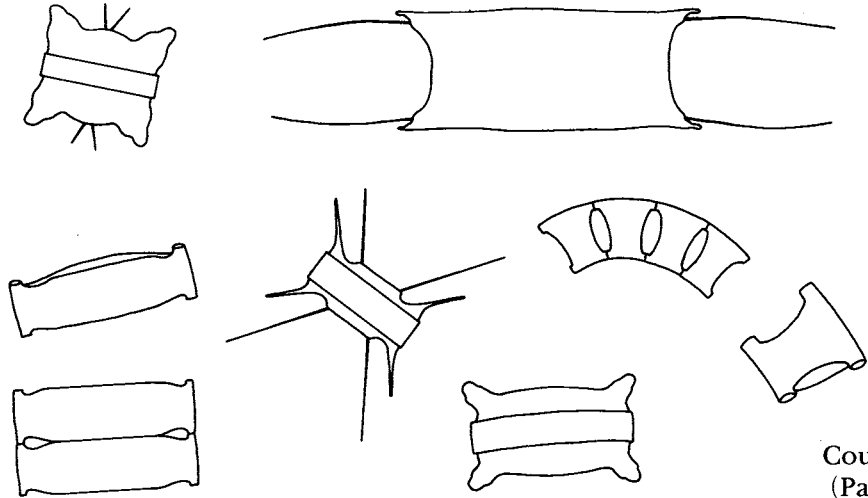
Couplet 32
(Page 456)

GROUP G Cell rectangular in girdle view, elliptical or cigar-shaped in valve view, with a *long spine projecting from each corner*
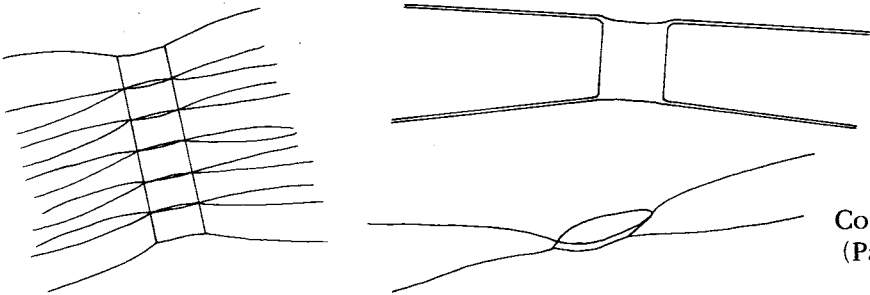
Couplet 36
(Page 460)

GROUP H Cell a *triangular prism;* may have a spine at each end
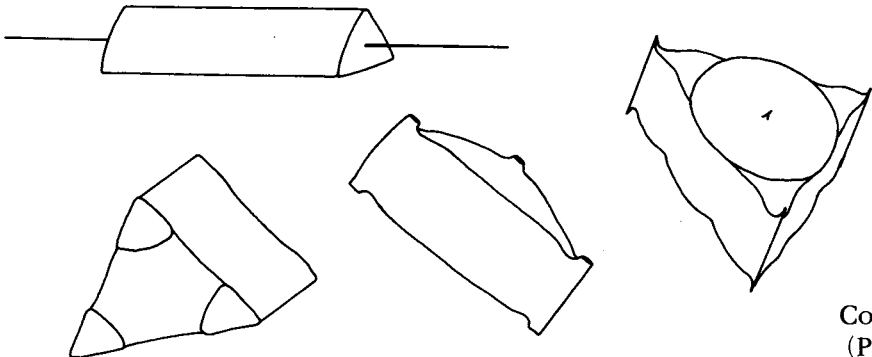
Couplet 39
(Page 463)

GROUP I   Cell *rectangular in girdle view, very narrow in valve view, without spines*. Cells
usually in flat or twisted ribbon-like chains
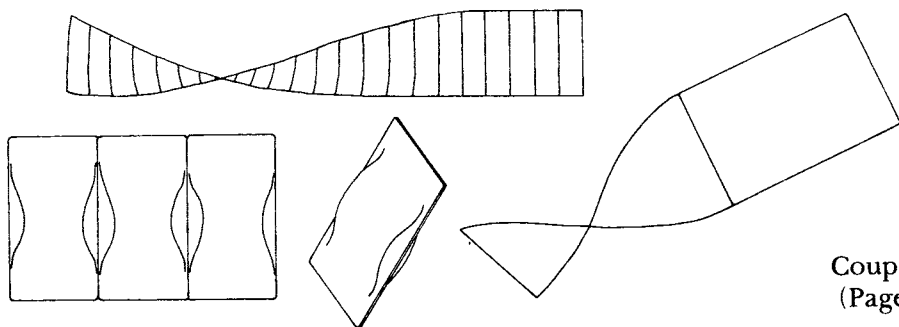
GROUP A

1.—Cells with projecting spines or mucilage threads, by which they are usually
joined to form chains
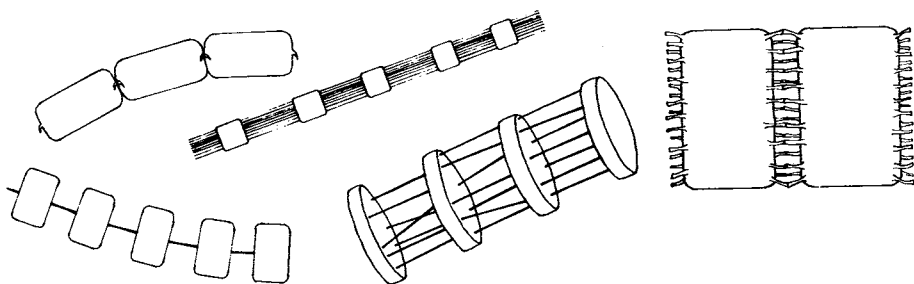
2

—Cells solitary or joined by their valve surfaces to form chains; lacking any
obvious spines or mucilage threads
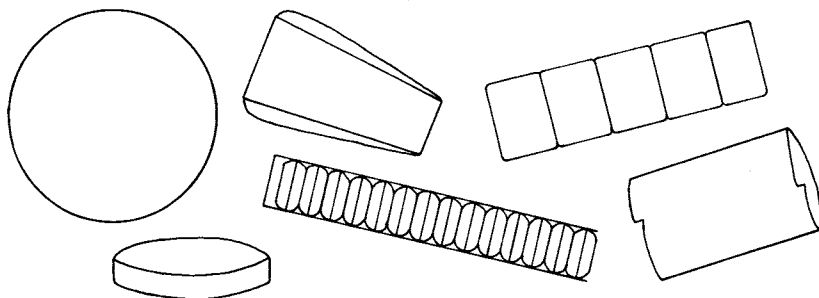
7

2. READ ALL THREE PARAGRAPHS

—Each cell cylindrical with a single, short, bent spine near its valve centre; cells usually united in loose chains
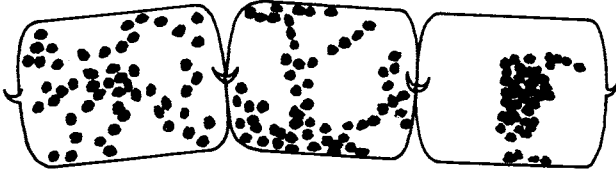
Rhizosolenia fragilissima
Valve diameter 12-60 μm; cell length 30-80 μm
(also keys out at 19)

—Each cell cylindrical with a ring of prominent spines around each valve margin
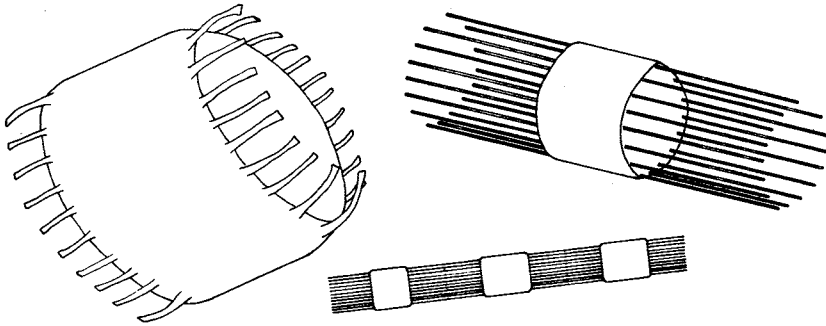
3

—Each cell disc-shaped with one or more mucilage threads issuing from its valve surfaces; cells usually united in chains by these mucilage threads
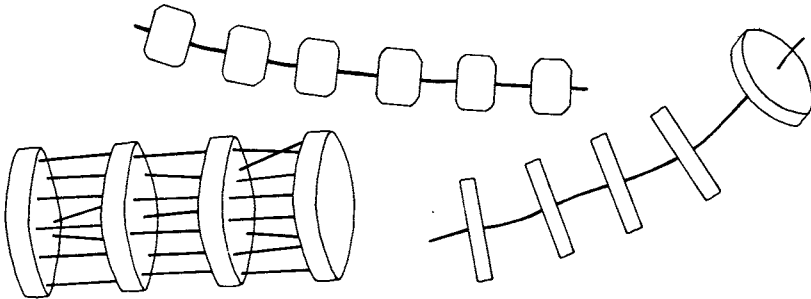
4

3.—Cells small, weakly siliceous. Spines relatively long, the spaces between cells often being longer than the cells themselves. Chromatophores—usually two small plates
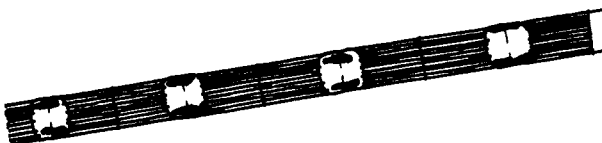
Skeletonema costatum
Valve diameter 8-15 μm; cell length 4-12 μm
(also keys out at 20)

—Cells large, with deep, rounded valve margins. Spines short and stout. Chromatophores—numerous small plates
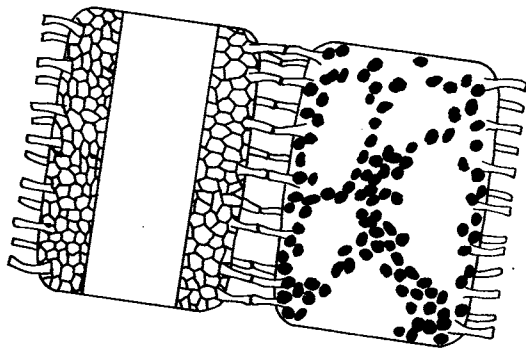
Stephanopyxis turris
Valve diameter 20-60 μm; cell length 40-90 μm
(also keys out at 20)

4.—Mucilage threads several
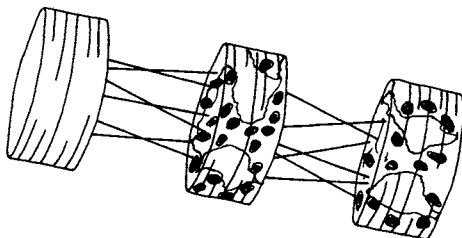
*Thalassiosira polychorda**
(=Coscinosira polychorda)
Valve diameter 25-75 μm

—Mucilage threads single   5

5.—Mucilage thread long; spaces between cells usually 3 or 4 times the distance between the two valve surfaces of one cell. Valves slightly convex, with areolae in curved lines
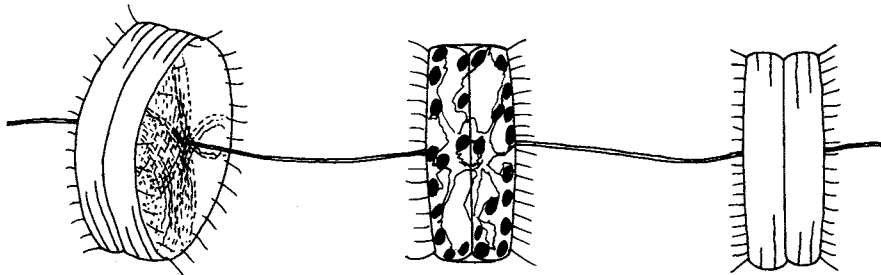
*Thalassiosira decipiens**
Valve diameter 12-40 μm; length of cell 8-18 μm;
length of mucilage thread 30-80 μm

—Mucilage thread shorter than above; areolae very faint   6

*See footnote on opposite page.

6.—Cell rectangular or almost square in girdle view, with rounded corners or with corners cut off to appear octagonal. Valve with a ring of very short, thin spines (usually 17) near the margin
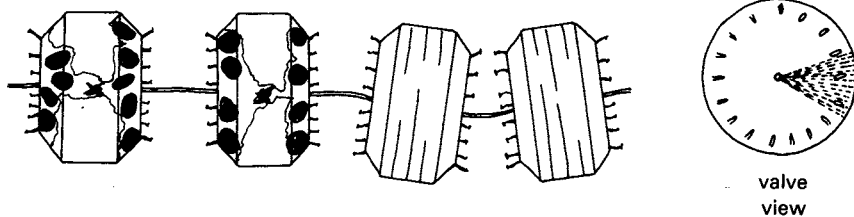
valve
view

Thalassiosira nordenskioldii*
Valve diameter 15-40 μm

—Cell rectangular in girdle view, with square corners. Mucilage thread thick. Valve surfaces scattered with very fine spines.
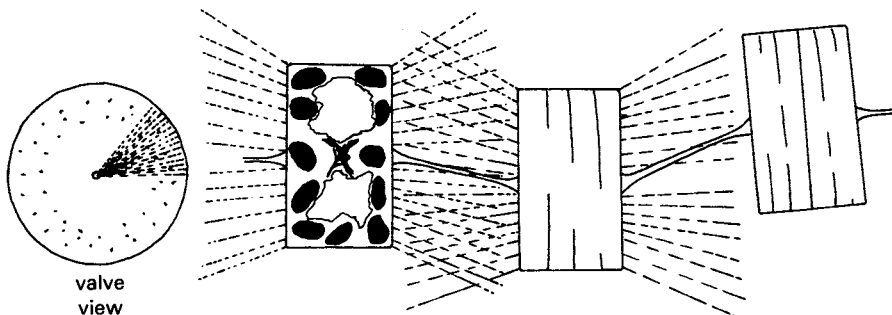
valve
view

Thalassiosira gravida*
Valve diameter 20-58 μm

7.—Cell disc-shaped, with girdle width (w) not more than one third the valve diameter (d)
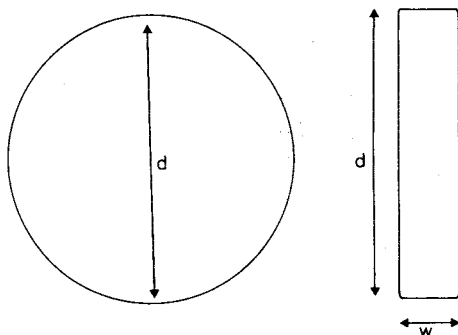
8

—Cell cylindrical, with girdle width (w) greater than one third the valve diameter (d)
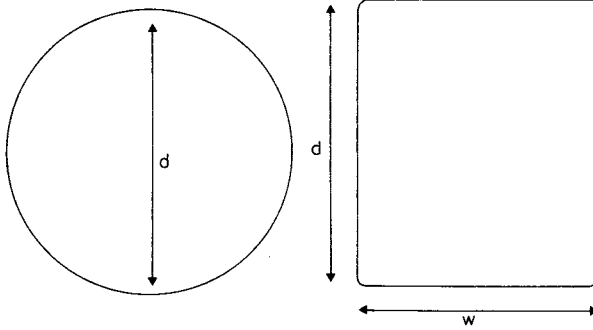
12

8.—Valve surface divided into sectors that are alternately raised and depressed
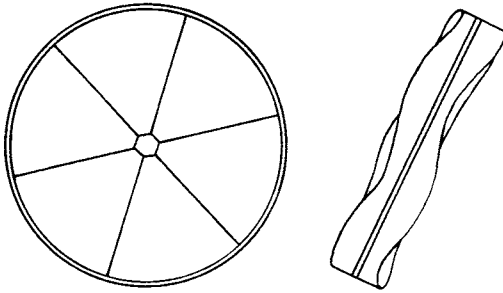
9

—Valve surface flat or smoothly convex   10

9.—Valve surface divided into six sectors, alternately raised and depressed. Sectors covered with coarse hexagonal areolae. At the centre of the valve is a small clear hexagonal area
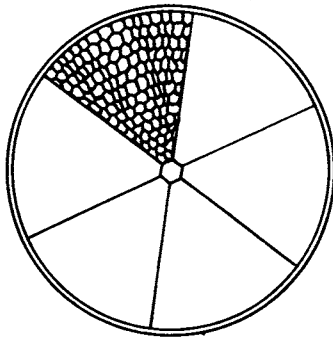
Actinoptychus senarius
Valve diameter 20-86 μm

—Valve surface divided into usually 18-20 sectors, alternately raised and depressed. Central clear area large, circular or star-shaped
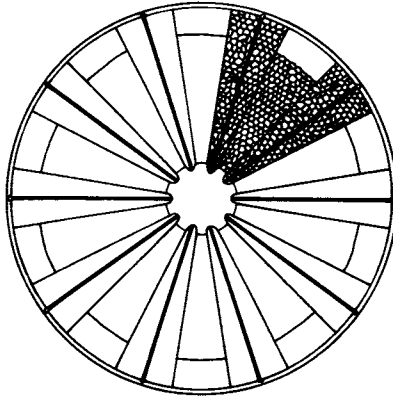
Actinoptychus splendens
Valve diameter 80-180 μm

10. READ ALL THREE PARAGRAPHS

—Valve convex, covered with very fine areolae. Girdle up to two times wider on one side of the cell than on the other
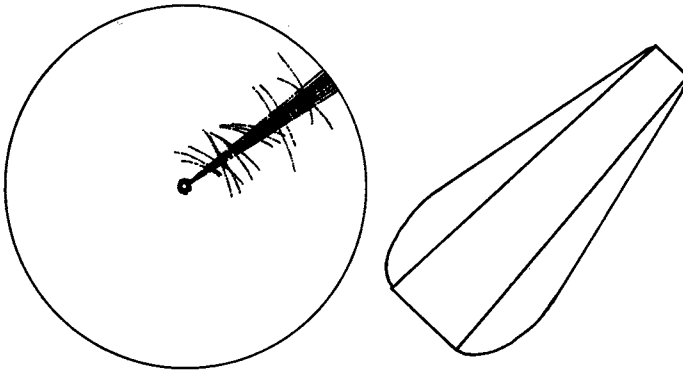
Coscinodiscus grani
Valve diameter 100-120 μm; girdle width—wide side 20 μm, narrow side 10 μm
(also keys out at 21)

—Valve flat, covered with coarse hexagonal or polygonal areolae. Girdle of the same width all round the cell

11
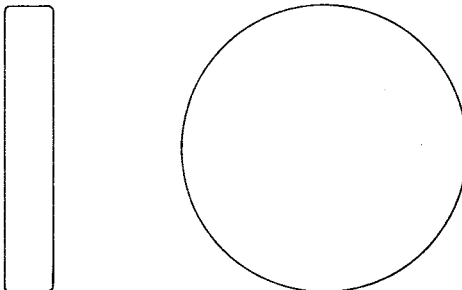
—Valve flat and clear in the centre, convex and coarsely areolate at the margin.
Cells usually united, valve to valve, in long straight chains
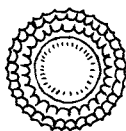
chain of
cells in
girdle view

valve view
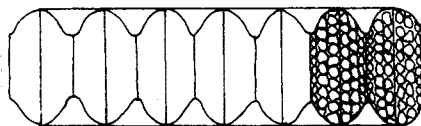
Paralia sulcata
Valve diameter 36-60 µm

11.   READ ALL THREE PARAGRAPHS

—Areolae in straight lines radiating from near the value centre
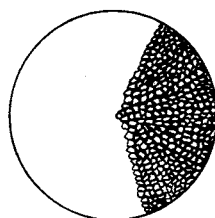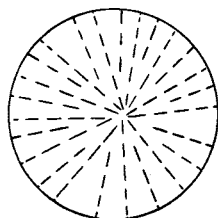
Coscinodiscus radiatus
Valve diameter 70-140 µm

—Areolae in straight, transverse lines, parallel throughout
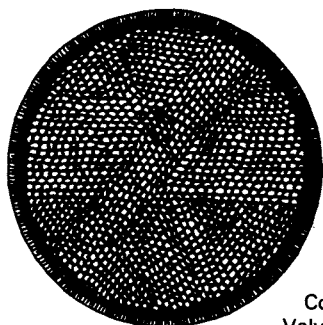
valve view
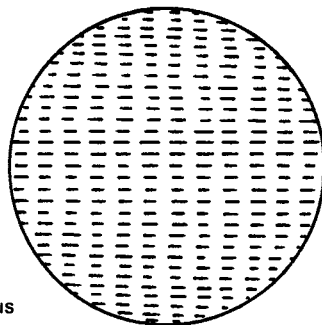
Coscinodiscus lineatus
Valve diameter 44-120 µm

—Areolae in parallel, curved lines, usually arranged in seven sectors, each based
on one of seven areolae surrounding the central one
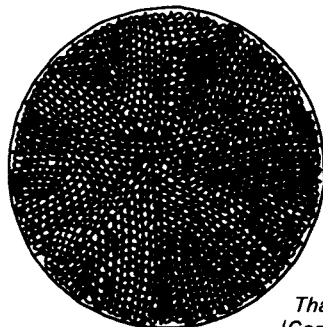
valve view
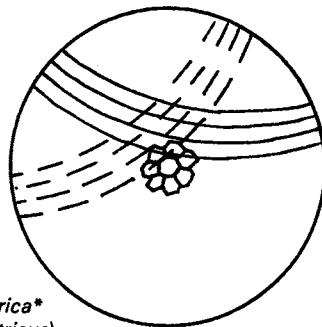
*Thalassiosira eccentrica**
(*Coscinodiscus eccentricus*)
Valve diameter 40-140 µm

*See footnote on page 441.

12.—Valve flat but with a noticeable step in girdle view
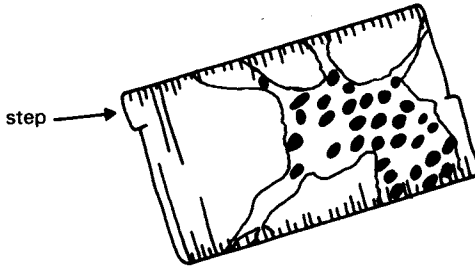
Guinardia flaccida
Valve diameter 36-80 μm; cell length up to 160 μm

—Valve flat, convex or concave but not stepped   13

13.—Valve gently convex; cells solitary and very large

Coscinodiscus concinnus
Valve diameter 300-465 μm

—Valve flat or weakly concave, with a marginal ring of very fine spines (not always visible at low magnifications). Cells often joined, valve to valve, in chain formation
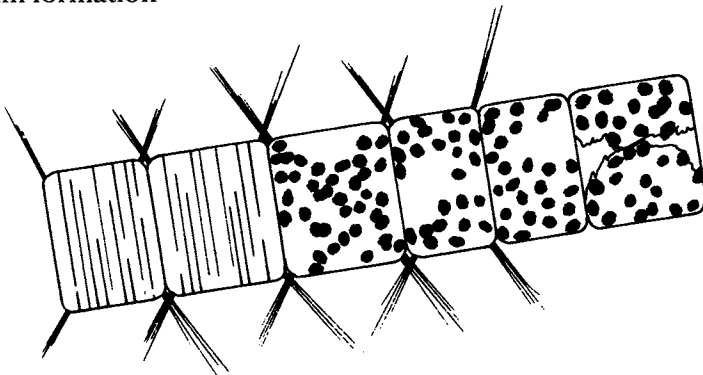
Lauderia borealis
Valve diameter 30-50 μm

GROUP B

14.—Cell with a long or short spine at each end
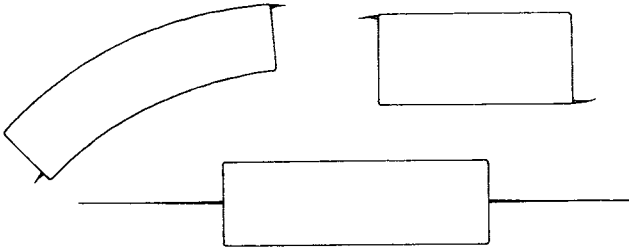
15

—Cell without spines   16

READ ALL THREE PARAGRAPHS

15.—A single long spine arising from valve centre. (A number of very small spines may also be distinguishable on the valve surface)
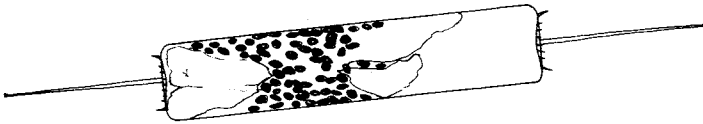
Ditylum brightwellii
Valve diameter 28-46 μm; cell length 80-130 μm;
spine length 20-50 μm
(also keys out at 39)

—Cell a straight cylinder with a short marginal spine

chain formation

Rhizosolenia delicatula
Valve diameter 16-22 μm; cell length up to 60 μm

—Cell a curved cylinder with a short marginal spine

in chain formation
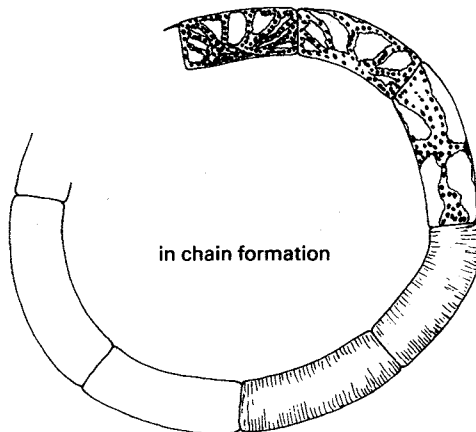
Rhizosolenia stolterfothii
Valve diameter 15-40 μm; cell length up to 130 μm

16.—Cell a long cylinder with a thin frustule; cells usually united valve to valve in short chains
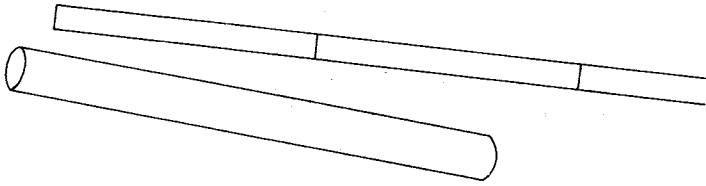
17

—Cell linear in valve view, a narrow rectangle in girdle view. Cells usually in block-like, zig-zag or star-shaped colonies
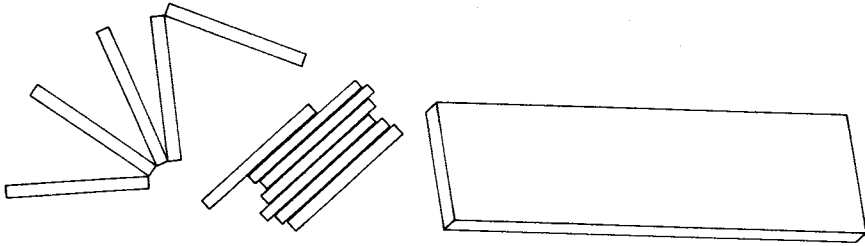
18

17.—Chromatophores—numerous small rounded bodies
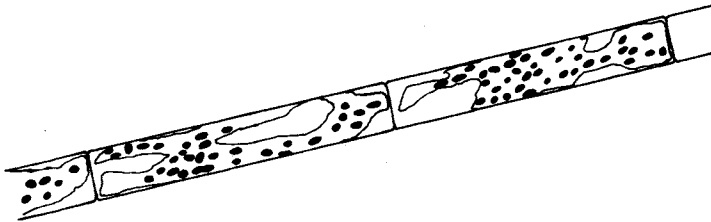
Leptocylindrus danicus
Valve diameter 5-16 μm;
cell length 30-50 μm

—Chromatophores—two plate-like bodies
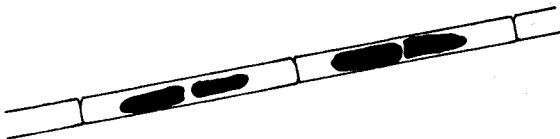
Leptocylindrus minimus
Valve diameter 5-6 μm; cell length 40-50 μm

18.—Cells united valve to valve in irregular block-like colonies. (Living colonies
      show a unique form of cell movement; the cells at one moment appear as a
      block-like colony then, with a gliding movement, rather like extending a
      slide rule, the cells slide over each other to form an elongated chain)
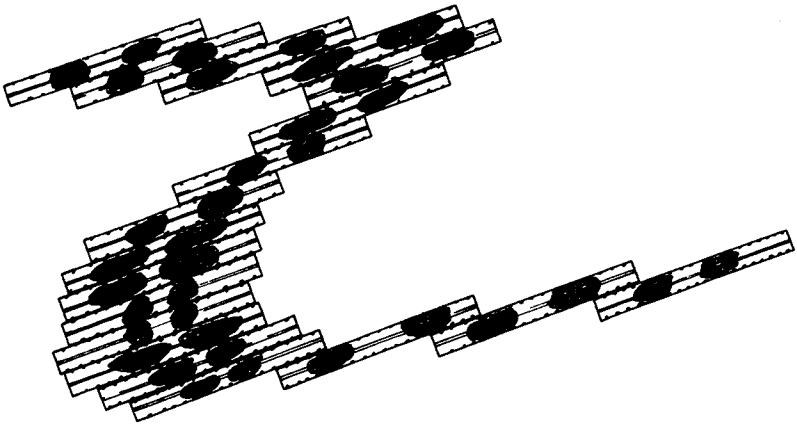
Bacillaria paxillifer
Valve length 70-100 µm

—Cells united by their ends in star-shaped or zig-zag colonies
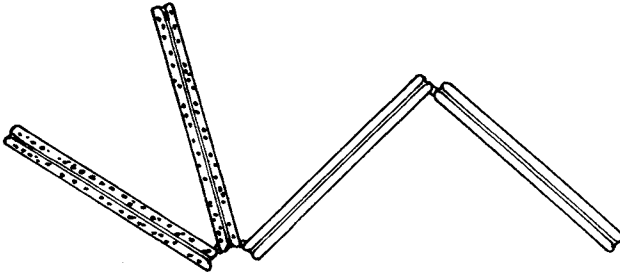
Thalassionema nitzschioides
Cell length 30-90 µm; breadth 2-5 µm

GROUP C

19.   READ ALL FOUR PARAGRAPHS
      —Cell with two short, blunt extensions to each valve margin, but without spines
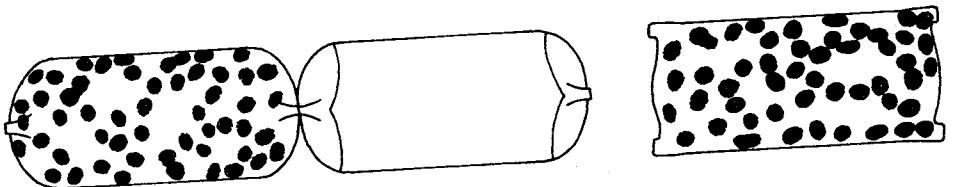
Cerataulina pelagica
Valve diameter 36-56 µm;
cell length 70-120 µm

—Cell with single short, bent spine near its valve centre
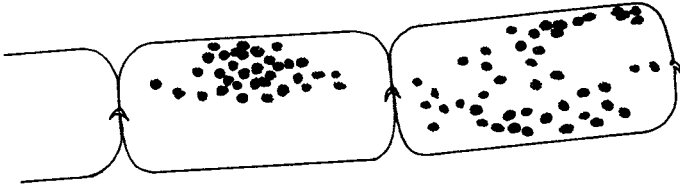
Rhizosolenia fragilissima
Valve diameter 12-60 µm; cell length 30-80 µm
(also keys out at 2)

—Cell with a ring of spines arising from the margin of each valve
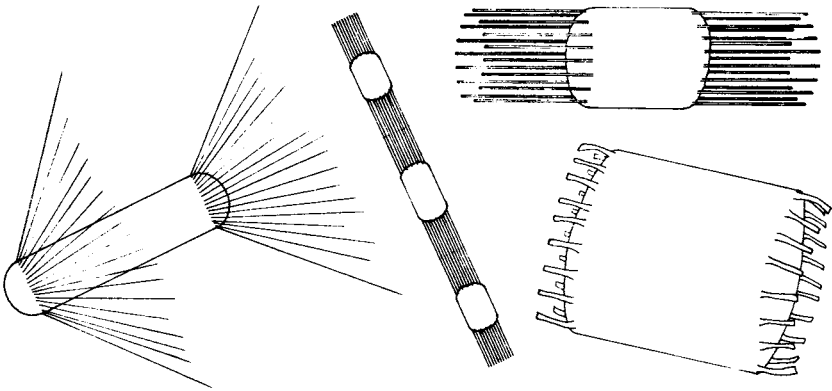
20

—Valve with no spines or extensions   21

20. READ ALL THREE PARAGRAPHS

—Cells small, weakly siliceous. Spines relatively long, the spaces between cells often being longer than the cells themselves. Chromatophores—usually two small plates
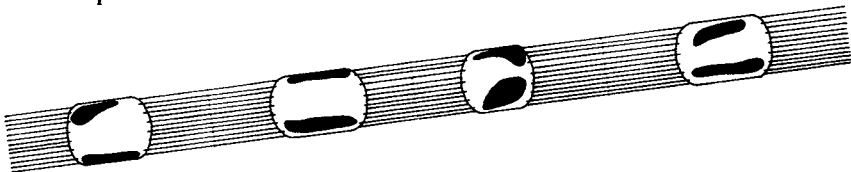
Skeletonema costatum
Valve diameter 8-15 µm; cell length 4-12 µm
(also keys out at 3)

—Cells large, with deep rounded valve margins. Spines short and stout. Chromatophores—numerous small plates
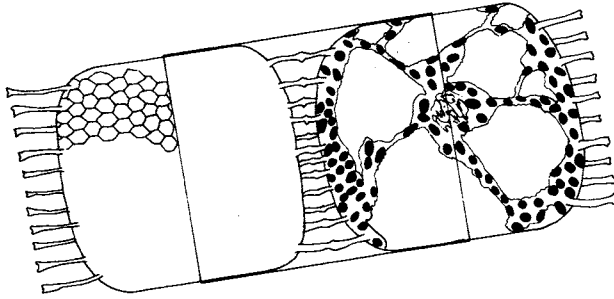
Stephanopyxis turris
Valve diameter 20-60 μm; cell length 40-90 μm
(also keys out at 3)

—Spines from both valves pointing in the same direction
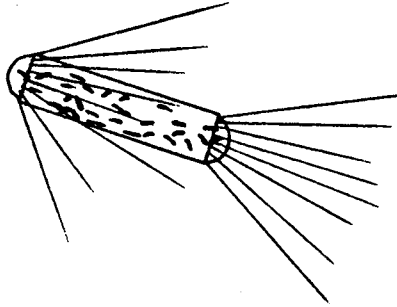
Corethron criophilum
Valve diameter 20-60 μm; cell length 40-240 μm

21.—Cell of unequal thickness, with the girdle up to two times wider on one side of the cell than on the other. Cells usually solitary
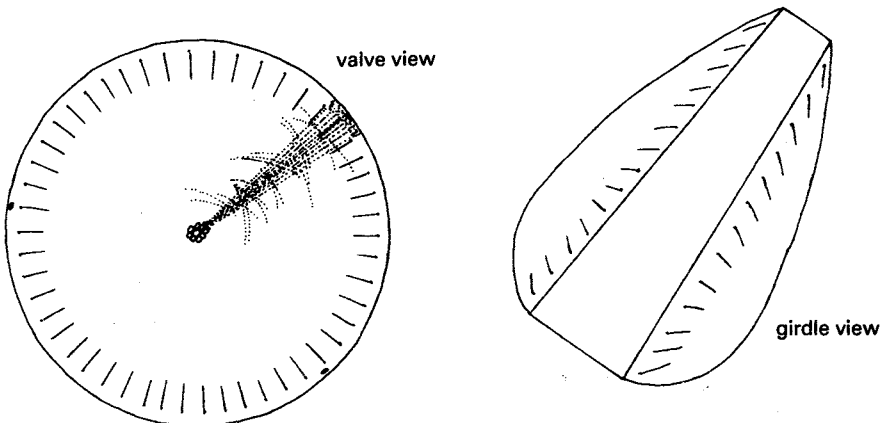
valve view

girdle view

Coscinodiscus grani
Valve diameter 100-120 μm; girdle width—wide side 20 μm; narrow side 10 μm
(also keys out at 10)

—Girdle of uniform width, cells usually in chains   22

22. READ ALL FOUR PARAGRAPHS
    —Cells shortly cylindrical, united in long straight chains
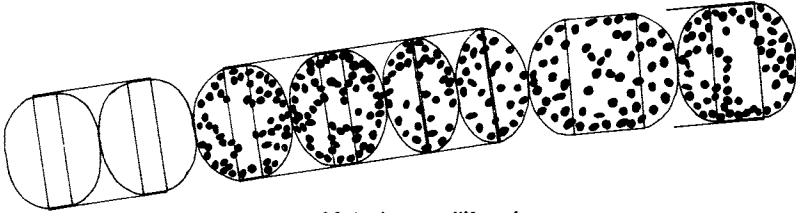
Melosira moniliformis
Valve diameter 30-60 µm

—Cells more or less elongated with strongly rounded valves, appearing almost globular. Each valve has a short siliceous collar. Cells usually united in short chains
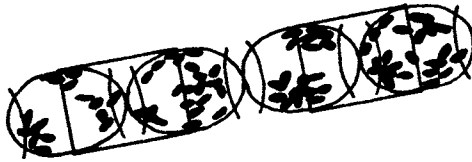
Melosira nummuloides
Valve diameter 28-34 µm

—Cells elongated with rounded ends and valve of uneven thickness; united in long straight chains

Melosira jurgensii
Valve diameter 12-20 µm

—Cell globular with a strongly ridged outline. Cells usually united in short chains
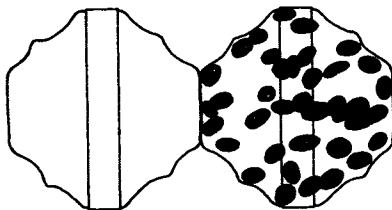
Melosira westii
Valve diameter 15-40 µm

GROUP D

23. READ ALL THREE PARAGRAPHS

—Cell swollen at one end only; usually in spiral, star-shaped colonies
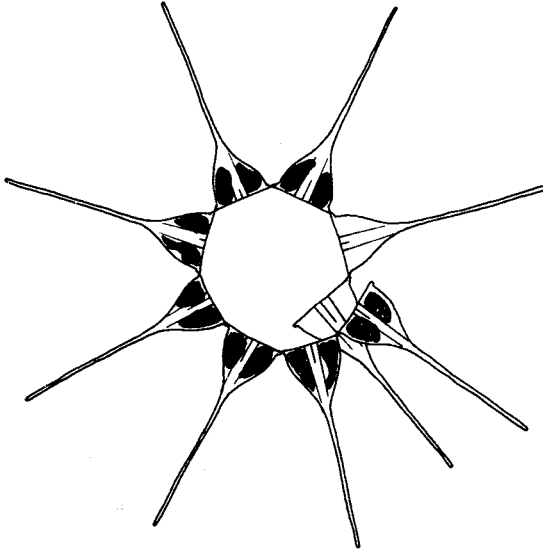
Asterionella glacialis
(= *A. japonica*)
Cell length 50-90 μm

—Cell swollen, unequally, at both ends; usually in star-shaped colonies
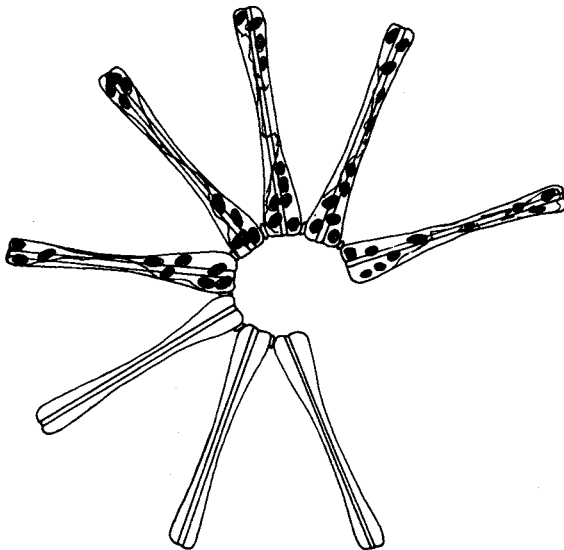
Asterionella bleakeleyii

—Cell swollen at one end and near the middle; usually in large-radius spiral colonies
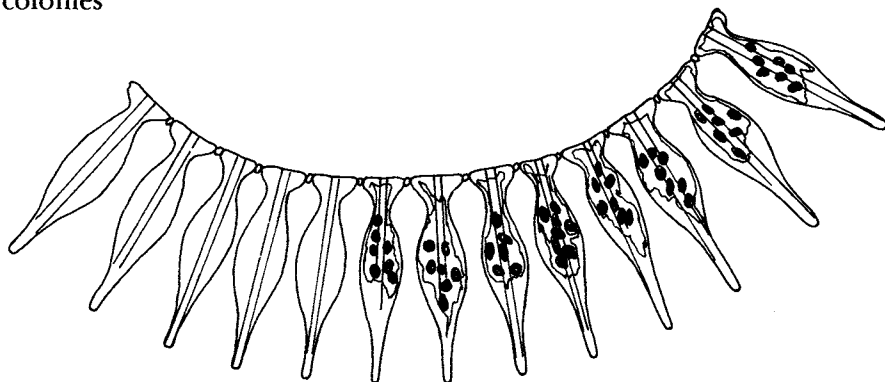
Asterionella kariana
Cell length 35-60 μm

Group E

24.—Cell with a distinct spine or finger-like extension at each end
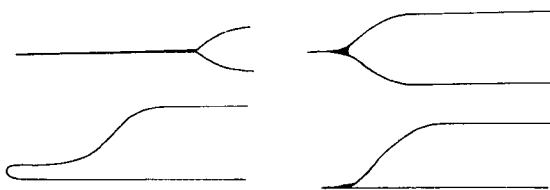
25

—Cell tapering to a sharp or blunt point at each end but with no spine or finger-like extension
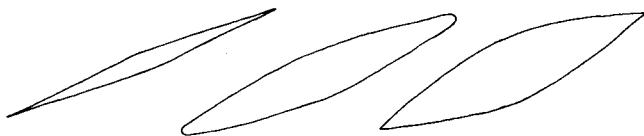
28

25.—Cell tapering from the middle towards each end; each spine usually at least twice as long as the swollen part of the cell
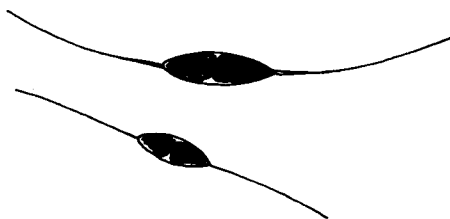
Cylindrotheca closterium
(= *Nitzschia closterium*)
Cell length 50-80 μm

—Cell with a long cylindrical portion, tapering only near each end. Spine or finger-like extension always shorter than the swollen part of the cell. Annular or scale-like markings may (or may not) be visible in girdle view. For reasons of clarity these are generally omitted from the drawings.
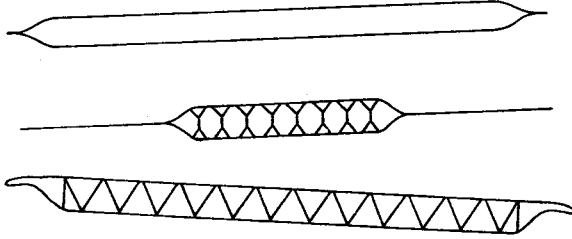
26

26.—Cell with finger-like extension at each end. The extension usually has living contents

Rhizosolenia alata f. *alata*
Valve diameter 8-15 μm; cell length up to 600 μm

—Cell with a solid, or partly hollow, spine at each end　　　　　　　27

27.　READ ALL FOUR PARAGRAPHS

　　—Spine long, straight or slightly curved, with a small internal cavity near its base

Rhizosolenia hebetata f. *semispina*
Valve diameter 5-12 μm

　　—Spine straight, long—each being up to one third total length of cell; no basal cavity
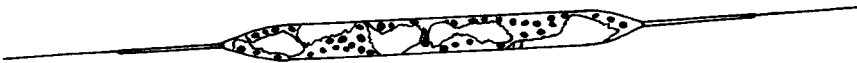
Rhizosolenia setigera
Valve diameter 8-25 μm; cell length up to 300 μm

　　—Spine short, with two lateral wings that extend down beyond the spine to fuse with the valve. Cells very large

ventral
view
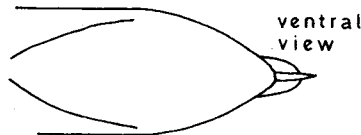
Rhizosolenia styliformis
Valve diameter 40-100 μm; cell length up to 1.5 mm

—Spine short, with two lateral wings that do not encroach upon the valve
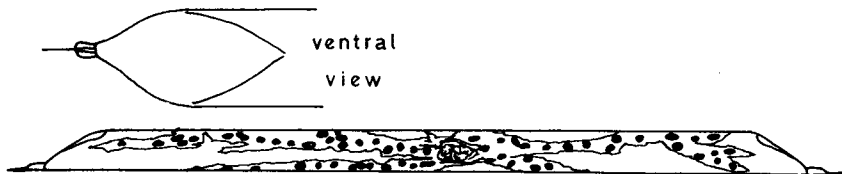
Rhizosolenia shrubsolei
Valve diameter 6-20 µm; cell length up to 300 µm

28.—Cell gently S-shaped in valve view

Pleurosigma spp.
Cell length 80-500 µm
(The genus *Gyrosigma* also keys out here; the separation of these two genera relies on minute characters)

—Cell spindle-shaped in valve view, being pointed at each end but with a straight long axis

29

29.—Valve with raised process at each end. Cells usually joined by these processes and their valve centres to form chains, leaving pear-shaped intercellular spaces near the ends of the cells
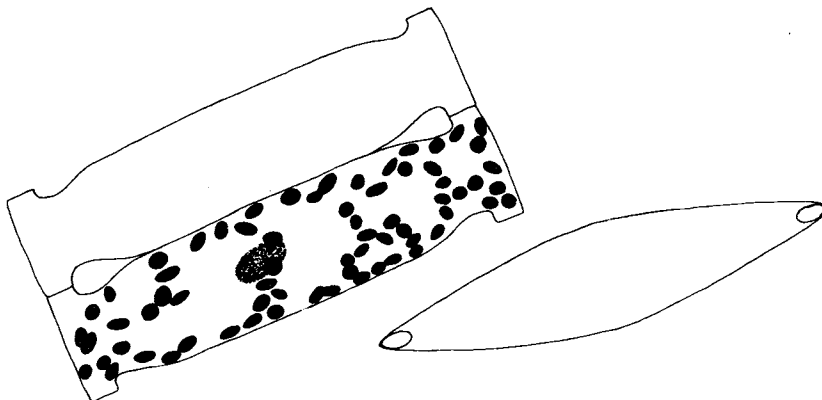
Bellerochea malleus f. *biangulata*
Valve length up to 110 µm; girdle width 20 µm
(also keys out at 35)

—Valve with no such raised process   30

30.—Cell showing typical pennate structure with distinct raphe and polar nodules. Cells usually solitary
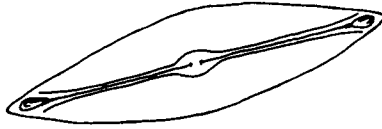
Navicula spp.
Valve length 7-180 μm
(Several other pennate genera may also key out here. These forms are difficult to distinguish and are not common in the plankton. They have therefore been omitted from this guide.)

—Pennate structure not readily visible. Spindle-shaped cells usually united by their tips to form filamentous colonies
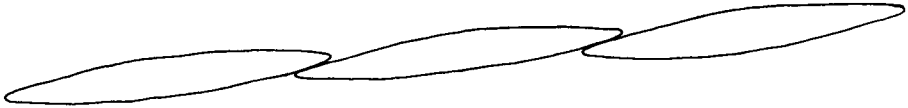
31

31.—Cell very thin and needle-like, gradually tapering to fine, acute apices
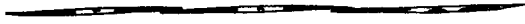
Nitzschia delicatissima
Valve length 55-90 μm; breadth 1.5-2 μm

—Cell more broadly spindle shaped; valve apices sub-acute, not finely drawn out

Nitzschia seriata
Valve length 90-100 μm; breadth 6-8 μm

GROUP F

32.—Each valve with two extended corners (processes) and two distinct spines
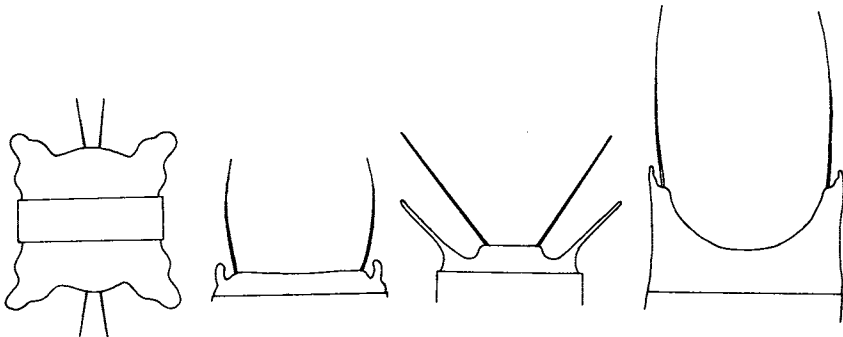
33

—Each valve with two extended corners (processes) but no distinct spines
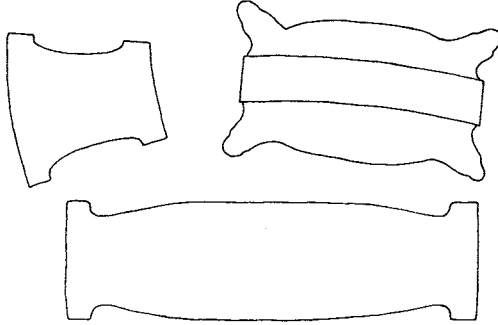
34

33. READ ALL FOUR PARAGRAPHS

—Processes short and stout; cells usually united by their processes to form zig-zag chains. Valve surface with swollen centre from where two (sometimes more) short divergent spines project

Biddulphia aurita
Valve length 20-54 μm

—Processes long and narrow, directed diagonally outwards. Central part of the valve surface flat, with two straight spines pointing outwards and almost parallel to the processes; spines set well apart and well removed from the processes
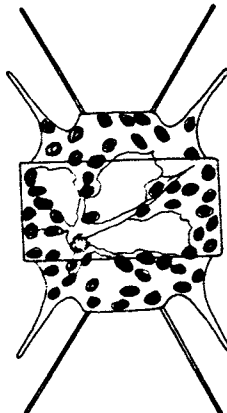
Biddulphia mobiliensis
Valve length 60-200 μm

—Processes short and weakly incurved. Central part of the valve surface flat or weakly concave, with two spines that arise close to the bases of the processes. The spines first diverge, then become weakly incurved particularly near their tips. Tips of spines usually broader and often split
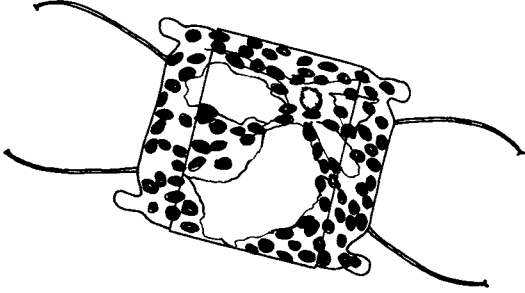
Biddulphia regia
Valve length 100-200 µm; breadth 60-90 µm

—Cell markedly pillow-shaped, being 2-2½ times as long as it is broad. Valve surface concave, with two spines arising close to the bases of the processes. Spines long, equal to or longer than the width of the frustule when seen in broad girdle view
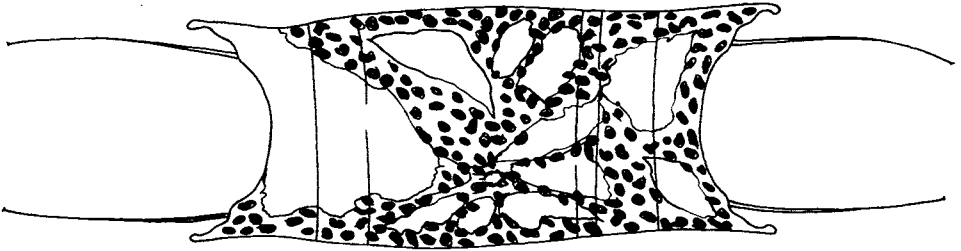
Biddulphia sinensis
Valve length 120-260 µm; cell length up to 300 µm

34.—Processes directed diagonally outwards and having rounded ends. Cells usually solitary. Girdle conspicuously raised; cell covered with fine but conspicuous areolae and sometimes having small spines scattered over the valve surface
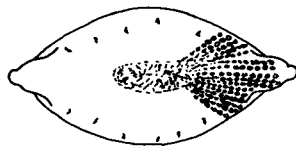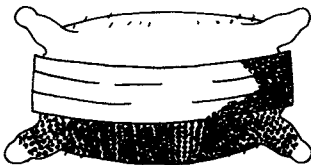
valve view

Biddulphia rhombus
Valve length 50-180 µm

—Cells usually in chain formation, with their flat-ended processes directed parallel to the axis of the chain
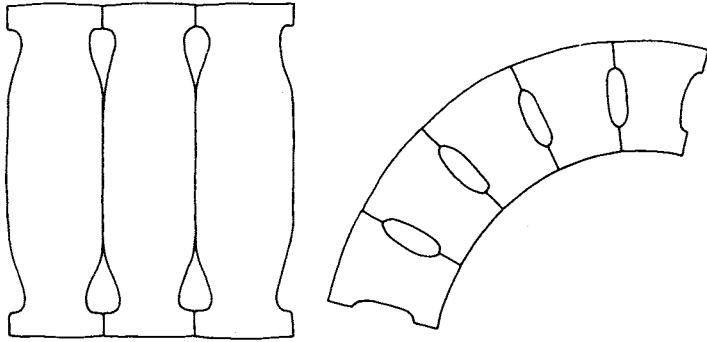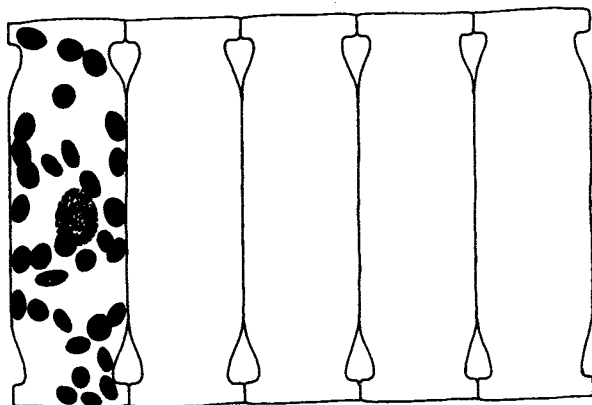

35

35.—Cells wedge-shaped in girdle view, joined only by their processes to form curved or spirally coiled chains
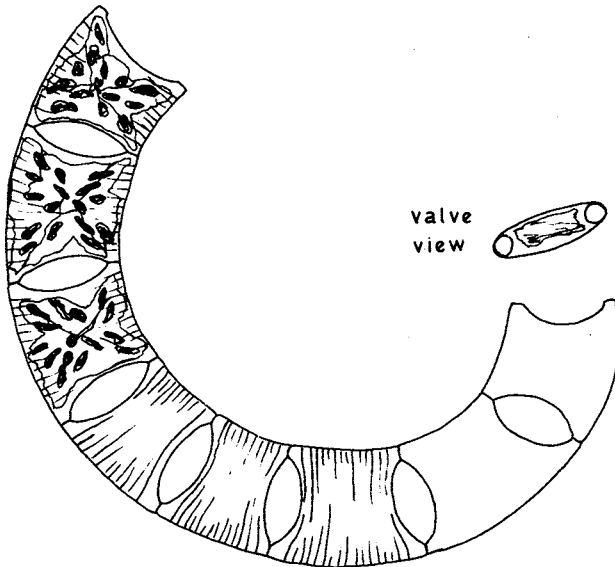
valve
view

*Eucampia zoodiacus*
Valve length 30-96 μm; cell breadth 40-50 μm

—Cells not wedge-shaped, joined by both their processes and their valve centres to form broad, straight chains, leaving pear-shaped intercellular spaces near the ends of the cells

Bellerochea malleus f. *biangulata*
Valve length 110 μm; cell breadth 20 μm
(also keys out at 29)

Group G

36.—Cell with numerous small chromatophores, some of which are inside the spines
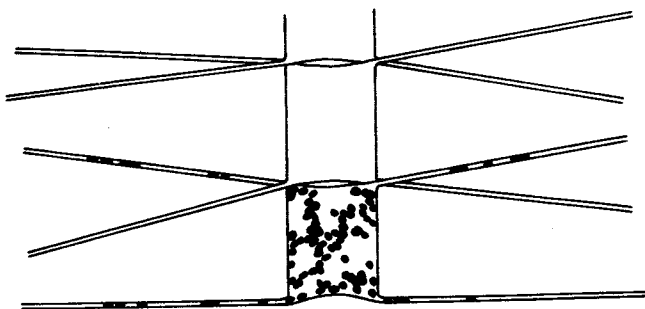
37

—Chromatophores one, two or several, contained within the cell cavity, never inside the spines
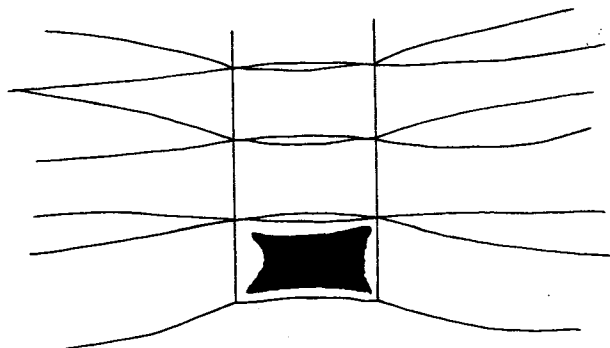
38

37.—Cells usually solitary but sometimes in short chains of up to eight cells. Spines straight, arising near the valve margin and held at right angles to the axis of the chain
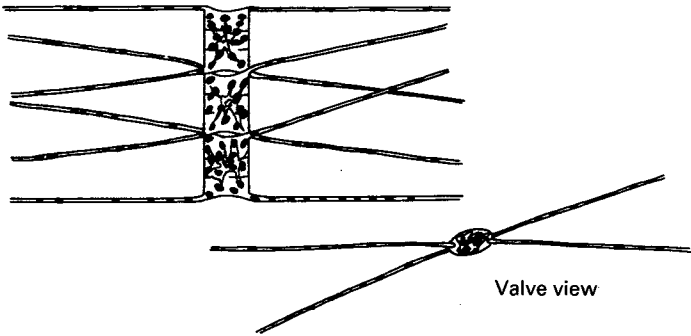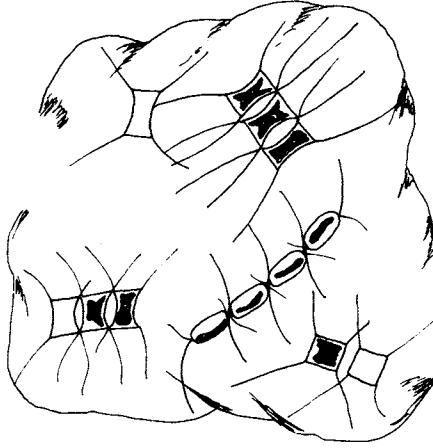
Chaetoceros danicum
Valve diameter 16-20 μm

—Cells united in short chains. Spines arise well inside valve margin, those of adjacent cells cross immediately and are directed outwards almost at right angles to the axis of the chain. Terminal cells in the chain differentiated; either with the end valve rounded and spines arising from the valve centre, or end valve flat with spines arising near the margin and pointing downwards almost parallel to the axis of the chain
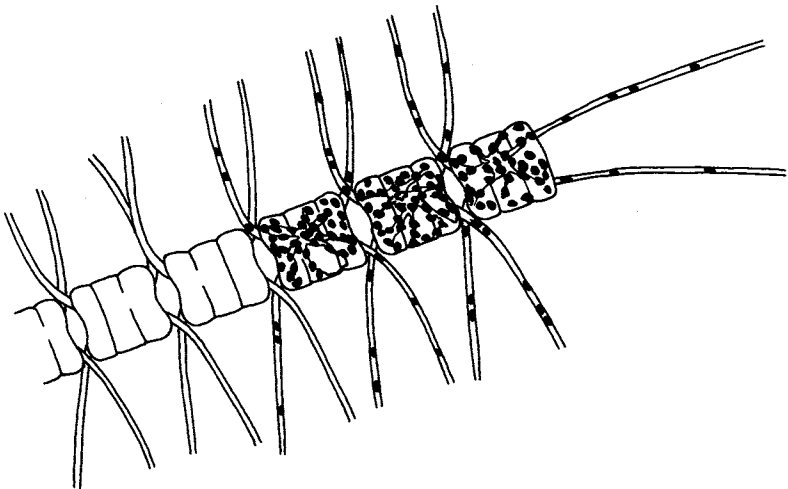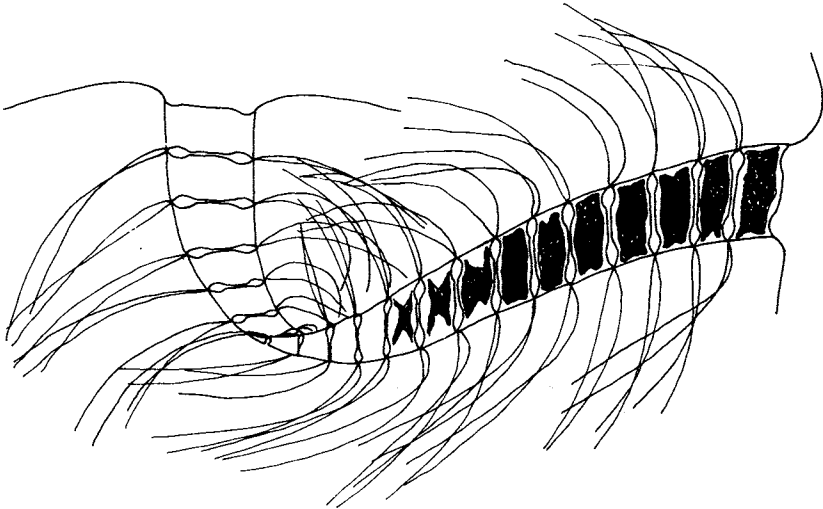
Chaetoceros densum
Valve diameter 15-40 μm

38.—Cells united in curved chains which are held together in large mucilaginous colonies. Spines very thin. Often of unequal length, crossing those of adjacent cells outside the girdle line

Chaetoceros sociale
Valve diameter 8-12 μm

—Cells united in long spirally twisted chains. Chains not in mucilaginous colonies. Spines thin and all bent over towards the same side of the chain
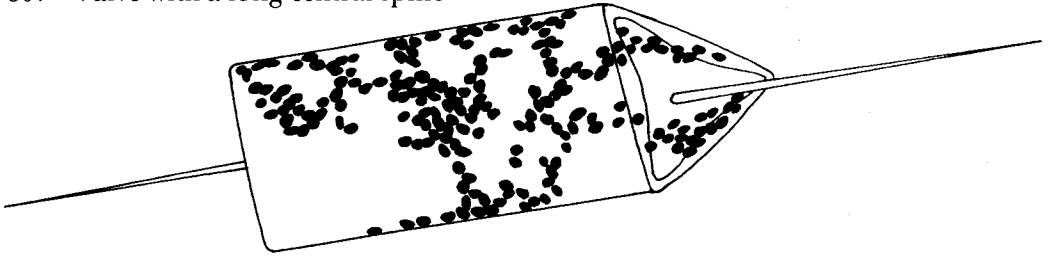

Chaetoceros debile
Valve diameter 12-30 μm

(*Chaetoceros* is a large genus and many other species may be encountered in British coastal waters. These are described and illustrated in Hendey 1964.)
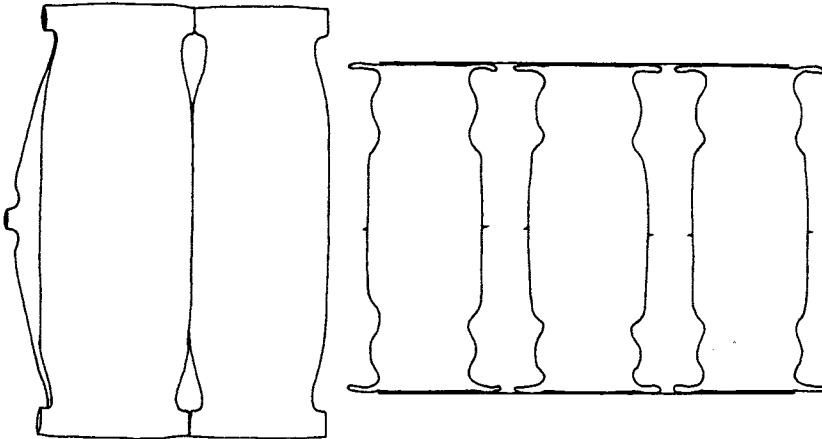
GROUP H

39.—Valve with a long central spine

Ditylum brightwellii
Valve diameter 28-46 μm; cell length 80-130 μm;
length of spine 20-50 μm
(also keys out at 15)

—Central spine very short or absent   40
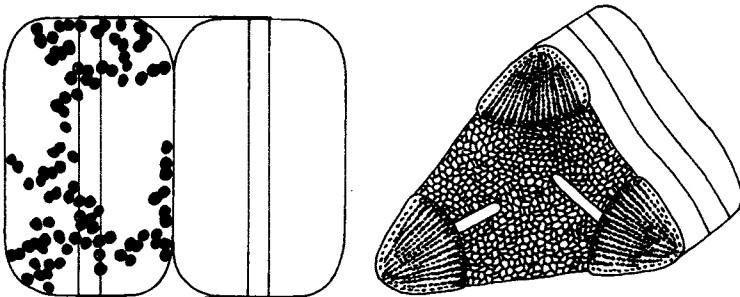
40.—Valve with a raised process at each corner. Cells usually in straight chains

41

—Valve without distinct processes but with corners slightly swollen. This appearance is often accentuated by the irregularly concave valve sides. Valve surface covered with a variety of sculptured lines and areolae. May form short chains


Biddulphia alternans
Length of valve side 36-45 μm

41.—Cell in girdle view basically rectangular, with undulating valve surfaces and a
     small, central spine on each valve. In chain formation, the intercellular
     spaces are nearly as wide as the cells
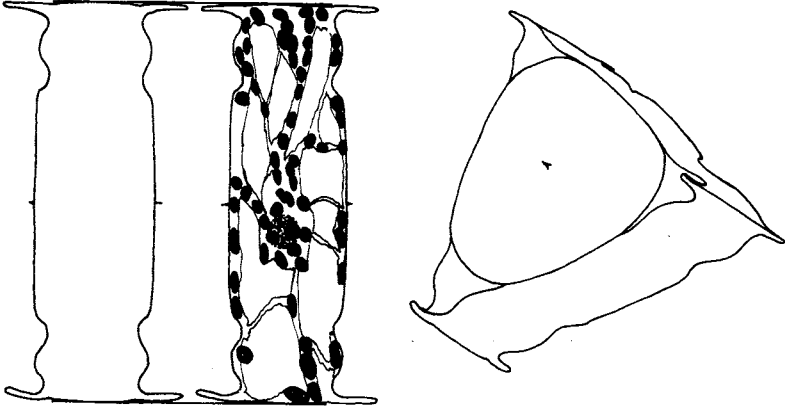
Lithodesmium undulatum
Length of valve side 40-60 μm

—Valve with no central spine. Cells united in straight chains by their processes
 and swollen valve surfaces, leaving only pear-shaped intercellular spaces
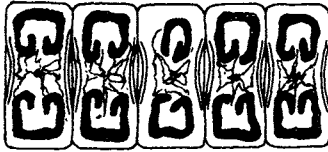 near each corner of the cell
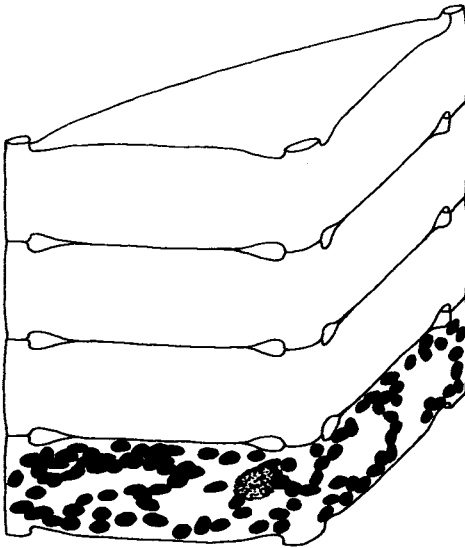
*Bellerochea malleus*
Length of valve side 110 μm

GROUP I

42.   READ ALL THREE PARAGRAPHS
—Cells usually united in stout, straight chains, Central area of valve thickened. Chromatophores—two undulating, ribbon-like bodies


Stauroneis membranacea
Valve length 60-81 µm; cell width 30-40 µm

—Cells usually united valve to valve in long, flat or twisted, ribbon-like chains. No central thickening to valve. Chromatophores—two plate-like bodies.
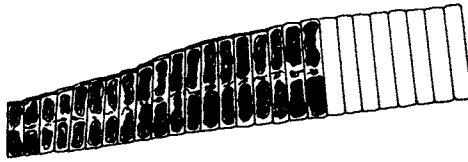
Fragilaria spp.
Valve length 3.5-80 µm; cell width 2-5 µm

—Cells very weakly siliceous, almost square in girdle view; united in long, usually twisted, ribbon-like chains. Chromatophores—numerous, small rounded bodies, arranged in lines radiating from the central nucleus
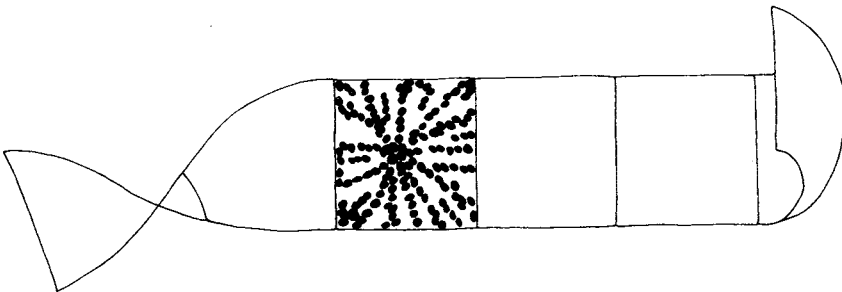
Streptotheca tamesis
Valve length 80-100 µm; cell width 90-120 µm

GLOSSARY

Annular: shaped like a ring (Latin *Annulus*).

Areolae: hexagonal or polygonal honeycomb markings in the
                                 surface sculpturing of many species.

Areolate: having areolae.

Filamentous: thread-like.

Phytoplankton: the plants of the plankton (see below), includes
                                 diatoms.

Plankton: the assemblage of living organisms floating freely in
                                 the sea (or freshwater) and moved passively by winds
                                 and currents.

Process: extended peninsula-like part of a cell.

Sculpturing: 3—dimensional patterns in the surface structure of
                                 the frustule.

Silicified/siliceous: impregnated and thickened with silica.

Zooplankton: the animals of the plankton.

INDEX OF GENERA AND SPECIES INCLUDED IN THE KEY.

The names and authorities are taken from Hendey (1974). Names inset and in parentheses are synonyms commonly used in older literature.

FIELD STUDIES COUNCIL
AIDGAP PROJECT
Nettlecombe Court
Williton
Taunton
Somerset TA4 4HT

A I D G A P
AIDS TO
IDENTIFICATION IN
DIFFICULT GROUPS OF
ANIMALS & PLANTS

The accurate identification of specimens is a fundamental part of most forms of biological fieldwork. Although the "popular" groups, such as birds and wild flowers, are well-served by numerous aids to their identification, others are often neglected. The reasons for this may vary but in general the subjects are considered too specialised and/or "difficult" and are, therefore, commercially less tempting.

The Field Studies Council, which runs 9 residential centres all of which specialise in fieldwork, is in a unique position to identify those groups for which the difficulty in identification is due to the absence of a simple and accurate key rather than to taxonomic uncertainty. The principal objective of the AIDCAP project is to produce such simple, well written aids to identification. These aids avoid obscure terminology and their format need not be restricted to the conventional (dichotomous) type of key; some currently being produced for AIDCAP use tabular or lateral guides such as that developed by Sinker (1975) in his "Lateral key to common grasses". However, the most significant difference between these and all other keys lies in the extent to which they are tested before final publication.

In addition to routine editing and refereeing by acknowledged experts, the keys are subjected to extensive field tests. Several hundred copies of a "test version" are printed and distributed to potential users—school and university staff and students, amateur naturalists, research workers and others involved in surveys who need to identify organisms in groups outside their own sphere of interest—the reactions of these "testers" are assessed and passed on to the author who amends the typescript before final publication.

The success of any project such as this depends on feedback from the public. Most people with experience of field work are aware of "gaps" in the literature but unless these are communicated to the project co-ordinator, AIDCAP can do little to help alleviate the situation. Anyone wishing to contribute identification aids, or to suggest possible subjects for future projects, should contact the co-ordinator at the address above. Projects need not be confined to the biological field; AIDCAP would be equally interested in geological, palaeontological and geographical subjects.

AIDCAP keys now published:
Hiscock, S. (1979). A field key to the British Brown Seaweeds.
Unwin, D. M. (1981). A key to the families of British Diptera.
Sykes, J. B. (1981). An illustrated guide to the diatoms of British coastal plankton. In preparation.
Sinker, C. A. and Bebbington, A. L. B. Identifying willows.
Cameron, R. A. D. A key to the slugs of the British Isles.
Crothers, J. H. and Crothers, M. A key to the crabs and crab-like animals of British inshore waters.